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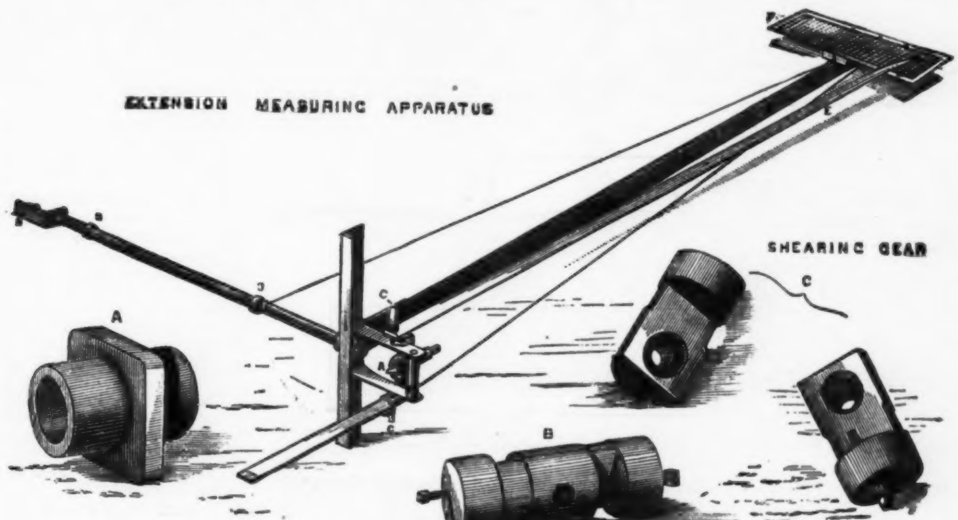
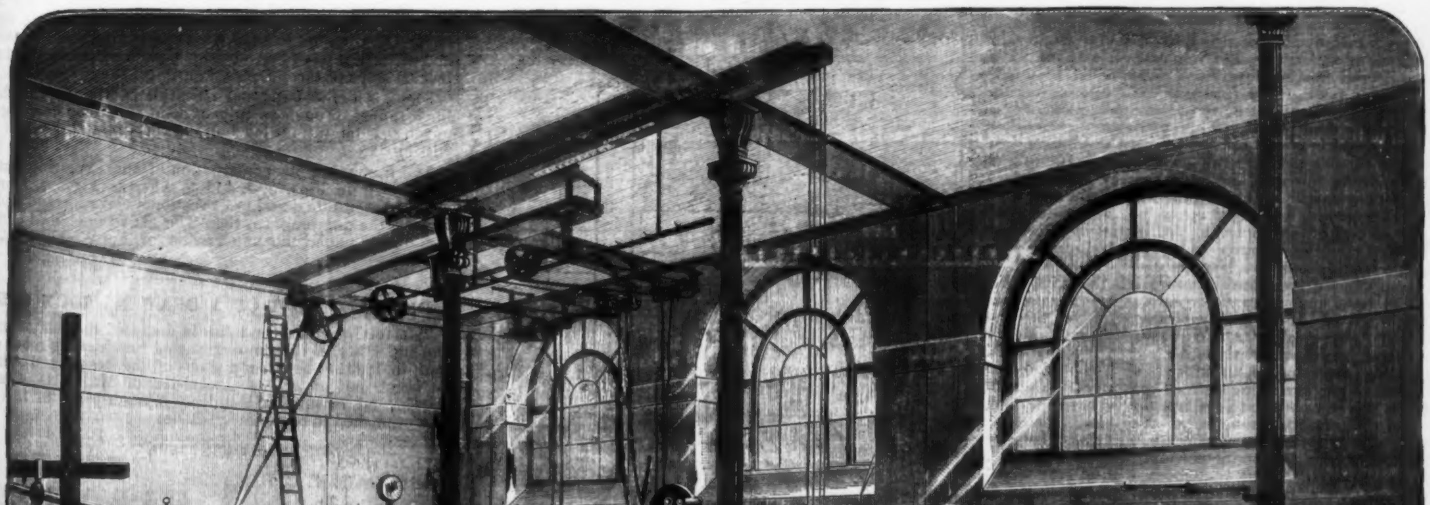
IMPROVED TESTING MACHINE.

A NEW wing has lately been opened in University College, Gower street, London. It contains art studios, a museum, and two fine laboratories. Space has been utilized to the utmost, a physiological lecture theater, of good proportions, being constructed in the roof and invisible from the ground. The wing was designed by Professor T. Hayter Lewis, and was built by Mr. W. Brass, under the direction of Messrs. Perry and Reed, and includes within its walls a lecture room for one hundred and seventy students and a microscope room for one hundred in the physiological department. The construction of this wing gave Professor Kennedy more room. His laboratory is on the ground floor, or rather partly below it, in another part of the building. The most prominent feature is the testing machine, of which we find the accompanying engravings and description in the *Engineer*. This is worked by manual power at present, and closely resembles Mr. Kirkaldy's machine in some of its features. It can exert a maximum strain of 100,000 lb., and can either stretch, compress, or bend a specimen to be tested. The machine was constructed by Messrs. Greenwood & Batley, Leeds. The strain is applied by hydraulic pressure, and the amount of the strain is measured by a dead weight acting through a system of levers. The maximum leverage is 100 to 1, and the maximum weight is 1,000 lb., 50 lb. of which are represented by the truck supporting the weight and running on the steel yard. Immediately over the machine is placed the optical arrangement for measuring very small extensions, devised by Mr. Willis, and already described and illustrated in our impression for May 30, 1879. Another apparatus used for measuring extension has been devised by Professor Kennedy, and is extremely elegant. It is shown below. Its construction can be readily made intelligible. It consists of a very light frame, D, stiffened by silk lines, and carrying a simple lever, E. This frame is secured by two light set screws, A B, to the specimen to be tested, an accurately-measured interval of, say, eight inches intervening between the points of the set screws. A light weight balances the gravity of the frame. The lever turns on the points of two screws, C C. To the end of the lever is secured a vernier, made of paper, and this vernier rests on a strip of "section paper," the lines on which work with the vernier. When the specimen is extended the two clamping screws are, of course, separated, and their motion is communicated to the lever, and in this way extensions of one ten-thousandth of an inch in eight inches are readily read off. So delicate is this apparatus that a half-inch steel rod is made by it to appear as elastic as a gas when under a strain of about two tons. If the counterpoise weight on the long lever of the steel yard be set swinging by hand like a pendulum, the hand of the extension measurer may be seen to move backward and forward with each oscillation of the weight. The gear for shearing strains is also shown in our cut. It consists of two half cylinders, B C, which can slide on each other in the socket, A. At B they are shown together, at C apart. The bar to be sheared is put into the holes shown, and B and C are then drawn apart, shearing the specimen in sliding over each other. The specimen cannot exceed in length the internal diameter of A. There is also in the laboratory an excellent machine for measuring the resistance of bars to torsion, and another, designed by Dr. Lodge, for illustrating certain electrical phenomena. The room is provided with lathes and drills, benches and vises, and students can here learn a great deal of the handicraft work of the mechanical engineer, besides much else.





PROFESSOR KENNEDY'S TESTING MACHINE.—UNIVERSITY COLLEGE, LONDON.

PNEUMATIC TUBE FOR MOUNTAIN RAILWAYS.

During the years that have elapsed since Medhurst, in 1810 and 1832, proposed his systems of propelling cars in tubes or tunnels by compressed air, many patents have been taken out on methods of connecting passenger cars with a pneumatic tube so as to afford a practical method of transit. The plan of Clegg and Samuda, patented in England in 1838, was one of the first invented, and still remains as good as any that have since been proposed. It was adopted on the atmospheric railways of Kingstown in Ireland, Croydon in England, and St. Germain in France. Along the upper side of the pneumatic tube there was a slit running its entire length. Over this slit was placed a strip of flexible leather fastened hinge like on one side. Beneath the continuous leather strip there were short pieces of iron plating placed end to end, which just fitted into the slit, and on the upper side were plates of iron somewhat wider than the slit. A knee-shaped piece of iron connected with the passenger carriage passed beneath this continuous valve, and was attached to a cylinder several feet long, which acted as a piston, fitting the inside of the pneumatic tube by means of an India-rubber flange. It was difficult to keep the apparatus in order and to prevent leakages, and notwithstanding a speed of over 30 miles an hour was attained, the enterprise was abandoned. Recently a modification of this system, said to be free from the defects of the former, has been devised and put in successful operation at an elevation of land called Plainpalais, near Geneva, Switzerland, for the purpose of affording to locomotives the increase of power necessary to pass over gradients greater than 1 in 30. This power is obtained by utilizing the pressure of air compressed in the tube, which is laid along the line of the railway. The pneumatic tube contains a movable piston, which is driven by the compressed air, and carries with it, through the intermedium of a rigid rod, the locomotive and the entire train. For a description and the figures of this apparatus, we are indebted to a writer in *La Nature*. The compressed air which is to be forced into the tube is stored in a large special reservoir; and, when the air has been driven into the entire length of the tube, it is forced back again into the reservoir by the descending train. The latter in its downward course drives the piston before it, thus creating a peculiarly sure and efficacious brake, while, at the same time, it restores, by compressing the air, the greater part of the motive power expended during the ascent of the preceding train. The work of descent of the trains is therefore utilized as completely as possible; and, if we take into consideration, on another hand, that the air compressors might be actuated by the waterfalls that are always numerous in mountainous countries, the same as they are now utilized in driving tunnels, it will be seen that the motive power can be obtained almost gratuitously. If a system of this kind, then, becomes really practical, it will lead to a large reduction in the cost of construction and exploitation of mountain railways.

The Plainpalais tube, which has a diameter of 9·9 inches, is laid, as shown in Fig. 2, in the middle of the railway on the same cross sleepers as the rails, the latter being elevated on longitudinal sleepers so as to bring them on a level with the top of the tube. The tube is strengthened by external ribs placed at equal intervals throughout its whole length (Fig. 1), and on its upper side there is a longitudinal slit designed to give passage to the drag bar which is fastened to the front of the piston that moves the train. It is necessary that the slit should always be kept closed behind in order to prevent any egress of the compressed air. This is effected by a sort of trapezoid valve, which forms one of the characteristic features of the system. This valve is raised at the moment the piston passes, and afterward presses hermetically against a seat of the same form which is made for it under the two edges of the tube. The greater the pressure in the tube, therefore, the more firmly the valve adheres to its seat and less is the danger of leakage. As may be seen in Fig. 3, the valve is connected by vertical rods to a flat piece of iron, which, when at rest, abuts against the tube; but when the two vertical lyre-shaped arms of the drag-bar pass, they raise this flat iron, as shown in the figure. After the passage of the bar, the piston, which then presents itself in its turn, puts the valve definitely on its seat. The piston itself is of cast iron covered with leather; in order to make it fit as tightly as possible, three grooves are made in the circumference, and in each of these is fitted a rubber ring covered with bands of leather which rub against the side of the tube at every point. The compressed air is driven into the tube under a pressure of six atmospheres, thus furnishing a motive power of about 6·5000 pounds, which differs little from the theoretical effort of traction of an ordinary locomotive with two driving wheels. The coupling of the piston with the locomotive arriving at the base of the ascent is effected with great facility and without switching, in the following way: The drag bar is connected with a small guide car running on small rails to the left and right of the tube, at C (Fig. 2), and which carries in front a fixed buffer designed to strike against a corresponding movable buffer connected with the locomotive. When the locomotive arrives the engineman lowers the movable buffer so that it comes in contact with the other, and the whole train is at once connected and carried along with the movable piston. On arriving at the top of the ascent the piston and its guide car come to a standstill, and the train pursues its onward journey without stoppage.

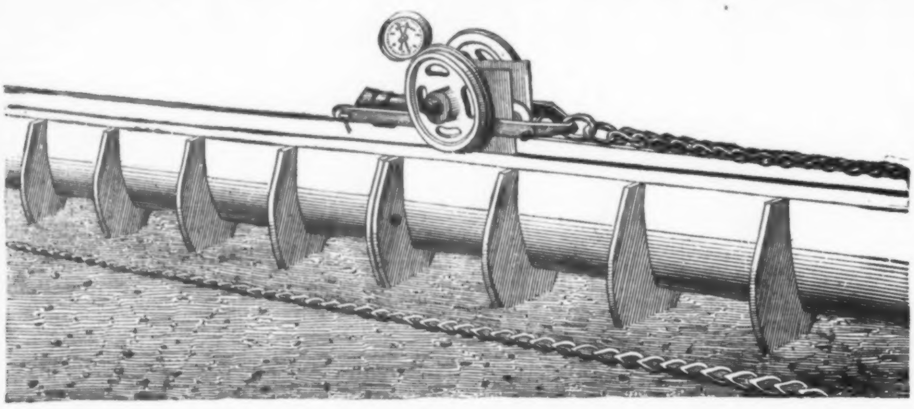


Fig. 1.—EXTERNAL VIEW OF THE PNEUMATIC TUBE.

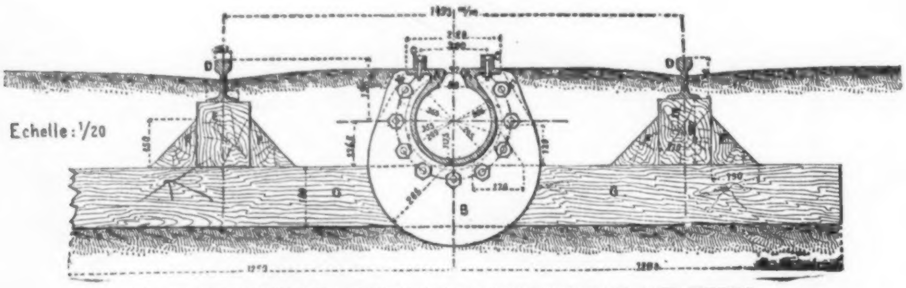


Fig. 2.—TRANSVERSE SECTION OF THE RAILWAY AND TUBES.

A. Cast-iron Tube. B. Ribs. C. Small Rails on which the buffer-car runs. E. Longitudinal Sleepers.

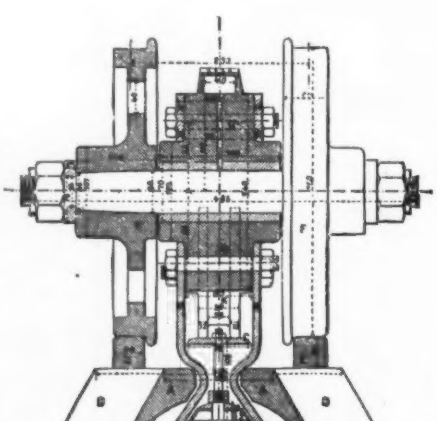


Fig. 3.—SECTION OF THE TUBE AND BUFFER CAR.

A. Cast-iron tube, and ribs, D. B. Longitudinal valve, composed of four parts: 1, convex band of iron; 2, covering of leather; 3, wooden portion; 4, plate of flat iron. C. Band of flat iron from which the valve is suspended. E. Rails of the buffer-car. F. Wheels of the same. G. Journal box. H. Double drag-bar, in form of a lyre. M, M_1. Section of the iron bars which form the piston-rod, and to which is fixed the drag-bar, K, L. Friction rollers which hold the valve during the passage of the bar.

THE BOTTROP CUT OF THE DUISBURG AND QUACKENBRUCK SECTION OF THE RHENISH RAILWAY (GERMANY).

To unite the stations Bottrop and Osterfelde of the Rhenish railway it was necessary to make a cut one and a half miles long, and having a depth of seventy-one feet in some places, through a ridge of green marl, clay, and gravel. As the nature of the soil required a slope of no greater inclination than 1 to 1¼, it is evident that the upper width of the cut must naturally be immense (in some places 200 feet), and consequently enormous quantities of earth had to be removed and transported to the dumping grounds to form embankments for the railway beyond the cutting. As this work had to be accomplished as economically and rapidly as possible the ends of the cutting were formed in the ordinary manner by carrying a gutter with steep sides forward in advance of the main cutting, which gutter was then widened and deepened to form the main cutting, whereas the earth of the middle and deepest part of the cutting (about one half mile long) was excavated according to the English method of excavating, which presented the most advantages in this case. A tunnel about eight feet high and ten feet wide was gradually worked into the heading of the cut and carried forward as rapidly as possible. The supporting frames for this exploring tunnel were made of old rails, and placed from three to three and a half feet apart, according to the nature and quantity of earth to be supported. The ceiling was made of one and a half inch pine planks, driven in in the manner shown in Fig. 4 of the opposite cut, taken from the *Zeit. d. Arch. und Ing. Vereins zu Hannover*. This tunnel was carried forward on the level of the future permanent line, and was provided with a central gutter.

From this exploring tunnel shafts were worked upward vertically to the top of the ridge or surface of the ground, at a distance of about thirteen to fifteen feet from each other, throughout the entire length of the tunnel. An earth car was placed under each shaft to receive the earth removed in constructing this shaft, and as the number of cars increased with the number of shafts, finally an entire train of earth cars was in the tunnel, which cars were removed when filled to be immediately replaced by others. Immediately after completion of a shaft the earth at its upper end was gradually loosened and thrown down through the shaft upon the car under it, and thus the upper ends of the shafts were gradually enlarged and deepened until finally the shafts were transformed into a series of parallel deep gutters extending across the entire width of the future cutting, and having their ends inclined the same as the slopes of the cutting. Nothing remained but the earth partitions separating these gutters from each other, and these partitions were then broken down and filled into the cars in the manner described.

The slope of the cutting was thus formed in a rough state, and was then packed, smoothed, and leveled.

The advantages of the within described method of excavating are that the soil need not be raised to be deposited in the cars, but drops or slides into the same by the action of its own weight, and need only to be loosened. This loosening of the earth can take place on the surface, and thus permits of employing a large force of laborers to work at the same time. The only underground work required is the digging of the exploring tunnel and of the vertical shafts.

The earth can be loosened and carried off much more rapidly than in any other manner of excavating, the level of the tracks for the construction road need not be changed continuously, as the railroad in the exploring tunnel will answer for the entire job, and earth slides cannot take place, and the great precautions required in ordinary diggings can be dispensed with.

In the opposite cut Fig. 1 is a longitudinal sectional elevation of the Bottrop cutting, showing the progress of the same. At the right hand side the end of the exploring tunnel and the first vertical shafts are shown; further toward the right the completed shaft and its funnel shaped upper end are illustrated, the adjoining shafts toward the left having been deepened and widened considerably at the upper ends. Next to these the slope in its rough state is shown, and at the left hand end of Fig. 1 we see the smoothed and leveled slope of the completed cutting.

Fig. 2 is a cross sectional elevation of the cutting, showing a tunnel through an embankment for a road crossing the cutting at the surface level and at the greatest depth of the cutting.

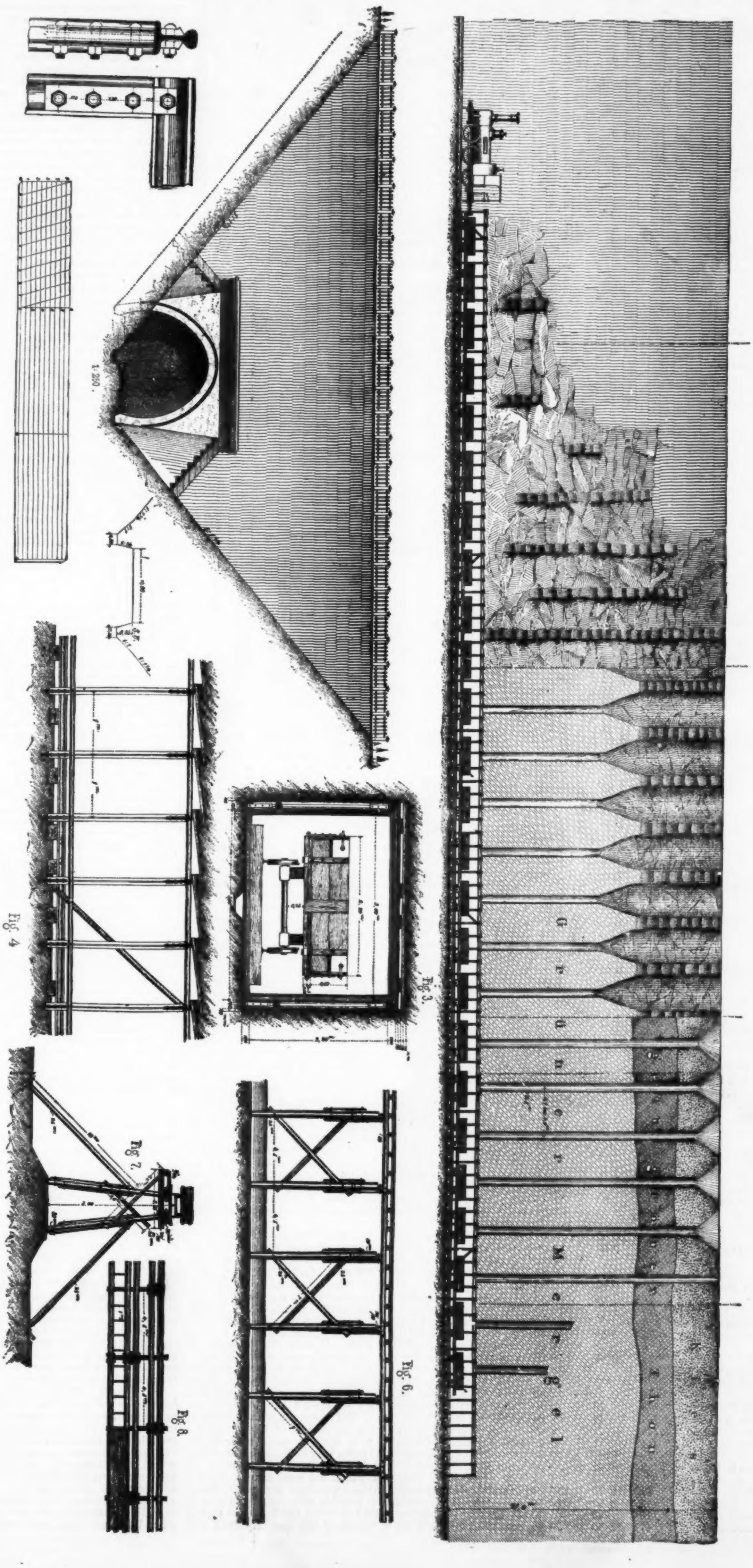
The frame and its construction of the exploring tunnel are shown in Figs. 3, 4, and 5, whereas Figs. 6, 7, and 8 show a longitudinal and cross sectional elevation and a plain view of the dumping trestle. The above described cutting was made under the supervision of F. Wiehl, C. E., of Essen.

DETAILED COST OF A DRAWING-ROOM CAR.

The following are the items in detail of the cost of material and labor in the shop of one of the drawing-room cars built in 1880 at the Allston shops of the Boston and Albany Railroad, and under the supervision of Mr. F. D. Adams, the General Master Car-Builder. A description of this car was published in our January issue:

COST OF TRUCKS.

Steel Axles (8) M. C. B. Standard.. lbs.	2,202	$0 07	$160 44
Allen Paper Wheels, 42 inch.......	12	100 00	1,200 00
Equalizers (8)...............lbs.	1,225	...	171 50
Elliptic Bolster Springs........lbs.	2,066	9	185 94
Vose's Graduated Equalizer Springs........................	8	....	85 00
Brasses, M. C. B. Standard.....lbs.	117	23	26 91
Channel Iron .... "	1,105	....	36 47
Pieces Beam Iron................	4	....	1 98
Box Covers, Springs, and Bolts..	12	26	3 12
Wrought Washers and Nuts.......	....	....	4 70
Wrought Iron ....lbs.	2,999	....	77 00
Brake Springs (8).............. "	57	6	3 43
⅝-inch Chain................. "	108	5¼	5 67
Screws.......................	....	...	23
Rubber Tubing	16	....	75
Castings.....................lbs.	3,476	3	104 28
Pine Lumber..................ft.	6	....	18
Oak " .... "	868	25 00	21 70
Paint Stock	....	....	5 00
Labor and Freight on Wheels, and Machine Shop Bill.................	....	....	43 60
Labor on Trucks.................	....	....	125 00
Total..................			$2,262 89



THE BOTTROP DEEP CUT, RHENISH RAILWAY, GERMANY.—DUISBURG AND QUACKENBRUCK SECTION.

COST OF CAR-BODY.

Ash Lumber ... ft.	1,780	$48 00	$85 44
Oak " ... "	526	25 00	13 15
Pine " ... "	3,800	25 00	95 00
Hard Pine Lumber	1,985	30 00	59 55
Whitewood "	2,400	36 00	86 40
Mahogany "	5,800	170 00	986 00
Castings ... lbs.	1,200	3	38 40
Wrought Iron and Washers "	1,700	2½	42 50
Plate Iron for Panels, etc. "	179	....	7 03
Hand Railing	227	3	8 31
Double Iron Body Bolsters. set.	1	....	34 90
Miller Hooks	2	16 37	32 14
" " Springs (2) ... lbs.	64	8½	5 28
" " Side Springs ... "	64	6½	4 16
" " Hook Buffers	2	5 31	10 62
" " Levers	2	1 62	3 24
English Sheet Iron ... lbs.	118	5½	6 49
Russia " " ... "	6	13	78 00
Galvanized Sheet Iron ... "	140	10½	14 70
Sheet Copper ... "	23	28	6 44
" Brass ... "	4	24	96 00
" Zinc ... "	27	7½	2 02
Tin ... sheets.	433	....	29 00
Bright Tin ... "	16	9	1 44
Solder ... lbs.	30	14	4 20
Rods for Hoods, etc ... "	11½	4	46
Tinned Nails ... "	4½	13½	61
Clout " ... "	6½	10	65
Bolts " ... papers.	⅛	30	15
Globe Ventilators, 5-inch	19	1 00	19 00
Cast Iron Ventilator Frames	17	8½	1 42
Coarse Wire Cloth ... ft.	5	18	90
Brass " " ... "	82	34	27 88
Copper Tacks ... papers.	7	15	1 05
Screws, Brads, etc	....	....	32 00
Nails	....	....	5 50
Machine Bolts	....	....	4 10
Lag Screws	....	....	2 70
Body Bolster Plates	2	....	1 50
Mixed Paint ... lbs.	60	10	6 00
Golden Ochre in Oil ... "	10	16	1 60
Burnt Umber in Japan ... "	3	28	84
" Sienna ... "	2	28	56
Lampblack ... "	3	20	60
Prince's Metallic Paint ... "	23	6	1 38
Putty ... "	8	6	48
Lead ... "	4	10	40
Fire Bronze (3 papers) ... "	¾	....	1 00
Corn Starch (for filling wood) ... papers.	40	9	3 60
Varnish ... galls.	4½	4 00	18 00
Shellac (2¼ lbs. to the gallon) "	7½	2 50	18 75
Oil, Boiled ... "	8	60	4 80
Turpentine ... "	3	47	1 41
Japan ... "	2	1 50	3 00
Benzine ... "	2	13½	27
Alcohol ... "	2½	2 14	5 35
Gold Leaf ... books.	40	35	14 00
Nickel " ... "	8	20	1 60
Chinese Vermilion ... paper.	1	....	08
Sand-paper ... sheets.	125	1	1 25
Plain Plate Glass, 36½×40 ... lights.	18	8 05	144 90
Ground " " " "	2	18 05	36 10
Figured for Toilet Room, 11×38. lights.	1	...	7 29
Figured for Door ... lights.	2	9 50	19 00
Plain Plate, 20½×36 "	4	7 65	30 60
Dome Sash, diamond cut, 18¾×6. lights	44	1 50	66 00
Cathedral Sash, 2×2 "	264	01½	3 96
Mirror, 17¾×33	....	....	5 41
Rubber Moulding ... ft.	280	3	8 40
" " Pins	....	....	50
Window Pulleys, $2.50 per dozen.	34	....	7 09
Window Sash Cord ... ft.	125	....	1 80
Stove-Pipe Ring, 7-inch	....	....	1 25
" " 8-inch	....	....	1 34
Bell Pull, Short	....	....	75
" " Long	....	....	1 25
Figures, Plated	63	....	5 52
Bell-Cord Pendants, complete	8	3 25	26 00
Bell Cord, Bushings	8	....	2 33
Sash Locks	19	75	14 25
" Lock Plates	36	....	3 00
Bar Pivots and Plates	38	....	7 12
Pivots and Plates for Deck Sash	4	....	1 00
Flush Bolts for Deck Sash	38	25	9 50
Bar Sash Lifts	38	75	28 50
Table Catches and 18 Plates	....	....	10 26
Table Braces, 18 Tips and Plates	4	....	18 00
Soap Dish	....	....	3 25
Tumbler Holder	....	....	3 50
Brackets for Foot Rests	24	1 62½	39 00
Rods for Foot Rests ... ft.	100	65	65 00
Match Strikers	6	...	2 38
Window Rods	2	2 87	5 74
Toilet Rod	....	....	1 87
Bolt and Catches for Heater	2	....	1 60
Brass Barrel Bolt for Heater	....	....	30
Screws, silver-capped, ⅝-in, gross.	6	1 25	7 50
" " "	3⅓	1 50	5 00
Notice-Plates, Outside Door	2	1 50	3 00
Locks, Outside Door	2	12 50	25 00
" Mortise, Inside Door	2	7 50	15 00
" Saloon Door	1	....	7 00
" Closet "	1	....	35
N'ght-Latches, Outside Door	2	6 00	12 00
Curtain Brackets	44	60	26 40
" Hooks	40	....	16 16
" Rings for Sliding	240	....	27 00
Catches for Deck Sash	4	50	2 00
Pulleys " " "	4	8	32
Ventilators, Hitchcock	14	2 00	28 00
Butts for Outside Doors, 4½×4 in.	12	....	14 25
" " Inside " 3½×3½ in	12	....	13 50
Butts for Closet Doors, 2½×2 in	4	10	40
" " Euchre Table, 3×3 in	4	40	1 60
Mirror Guard or Rack	....	....	9 00
Brass Hooks and Eyes	4	11	44
Wire Door-Screens	....	....	10 94
Oval Bell-Cord Pulleys in Hood	2	42	84
Antique Gimp ... pieces.	1½	....	7 31
Maroon Turkish Satin ... yds.	80⅛	2 70	216 84
Old Gold Silk Plush ... "	13¾	4 00	55 50
Cord ... "	115	45	51 75
Fringe ... "	47¼	1 60	76 00
Tassels	40	1 00	40 00
Maroon Silk Thread ... lbs.	1/12	8 00	67
Brown " " ... "	¼	8 00	2 00
Upholstery ... yds.	30⅜	4 13	125 30
Leather, 2 hides ... ft.	105½	27	28 49
Gros Grain Silk Ribbon ... pieces.	7½	1 00	7 50
Silk Thread ... boxes.	1⅓	1 30	1 65
" " light range ... lbs.	⅙	9 00	3 00
Hartshorn Rollers	22	....	7 79
Rods	...	....	1 05
Axminster Carpet ... yds.	77 5/16	3 25	251 26
Floor Paper ... "	30	...	1 12
Brass Grummets ... gross.	1¾	2 70	4 72
Binding ... "	¾	5 50	4 12
Basting Thread ... spools.	11	3	33
Linen " ... lbs.	1⅛	1 50	1 69
Hassocks	6	2 25	13 50
Axminster Rugs	2	3 60	7 20
Bordered Mats	2	4 10	8 20
Rubber Mats	2	3 00	6 00
Oil Carpet ... yds.	¾	1 25	94
Baker Heater & Pipes	....	....	325 00
Westinghouse Automatic Brake	....	....	138 00
Plated Cuspidores	18	....	32 25
Center Lamps, Williams, Page & Co., 4 burners	4	75 00	300 00
Side Lamps, complete	1	....	6 50
Smoke Bell for Side Lamp	...	...	1 25
Racks for Window Panels	12	8 00	96 00
Hat Hooks	19	1 50	28 50
Plumbing	....	....	172 81
Labor on Car-Body	....	..	2,269 17
Mahogany Chairs	36	9 27	333 72
Ash Lumber ... each chair.	....	10	3 60
Silver Plated Bands ... " "	....	87	31 32
Plush ... " "	....	15 15	545 40
Screws ... " "	....	7	2 52
Paint Stock ... " "	...	9	3 24
Castings ... " "	....	1 08	38 88
Cotton Cloth, etc. ... " "	....	15	5 40
Upholstery Shop and Labor, each chair.	....	18 10	651 58
Total Cost of Car-body and Furnishing			$8,479 87

RECAPITULATION.

Trucks:			
Material		$2,094 29	
Labor and Freight on Wheels		43 60	
Labor		125 00	
			$2,262 89
Body:			
Lumber		$1,325 54	
Iron, etc.		350 53	
Paint Stock		84 97	
Glass		313 26	
Furnishings		496 20	
Upholstering		924 23	
Miscellaneous		1,100 31	
Labor		2,269 17	
			6,864 21
Thirty-six Chairs:			
Material for each	$26 78	$964 08	
Labor for each	18 10	651 58	
			1,615 66
Total cost of car			$10,742 76

—*National Car Builder.*

THE VALUE OF A VACUUM.

A FEW months ago, when describing the performance of a compound portable engine constructed by Messrs. Richard Garrett & Sons, of Leiston, we had occasion to state our belief that if the engine in question had been fitted with a condenser its economy would not have been increased. To this statement some exception has been taken; and it is not easy to induce engineers to accept as true the assertion that a condenser can do harm. Nevertheless we have excellent reasons for adhering to what we have said, and reasserting that under certain conditions it is more economical to exhaust steam directly into the atmosphere than it is to condense it. This is a truth which is only just beginning to dawn on the minds of engineers, who are as reluctant to receive it as they were to accept the dictum that nothing is to be got by expanding steam more than about eight times, and that under most conditions a sixfold expansion is as good as any other. Within the last few days a case has come to our knowledge in which a large compound engine was fitted with a condenser. Owing to a difficulty in getting water, this engine was worked for some months non-condensing, the consumption of fuel being about 3·75 lb. of coal per horse per hour. When water was at last obtained the condenser was started, the load on the engine remaining unaltered, and the result was that the consumption of fuel went up to 5·25 lb. per horse per hour instead of falling. We have no reason to doubt that in a very large number of cases condensers are adding little or nothing to the economical efficiency of the engines to which they are fitted. If they pay the interest on their first cost, that is about all. We propose here to consider what is the maximum value of a condenser, and to point out the conditions which render its use injurious rather than the reverse.

It is evident that no matter what the conditions under which steam is used in an engine, the work done by condensation cannot exceed in value that which would be performed by the atmosphere if it were admitted to the cylinder. Let us suppose, for example, that we gradually admit 1 lb. of steam of atmospheric pressure under a piston. It will finally occupy a volume of 26·36 cubic feet, and will, during its admission, exert a pressure of 2116·8 lb. per square foot. Let the piston have an area of 1 square foot, then 1 lb. of steam will raise it 26·36 ft. high. If now the steam be all condensed, and neglecting the space occupied by the water, the air pressing on the piston will force it down, and the work done will be $26·36 \times 2116·8 = 55{,}799$ foot-pounds. If we employed steam of higher pressure than what would just balance the atmosphere, then we should have to apply an additional load to the piston. But inasmuch as the condenser can only operate by relieving the piston of the opposition which would be offered to it by the air, and the air represents what for practical purposes may be regarded as a constant load, we cannot deal with the question before us on any other basis than that which we have taken. Higher pressures we may have, but an extra load we cannot have; consequently the maximum possible value of a condenser is 55,799 foot-pounds per pound of steam condensed in it, and care must be taken not to confound this quantity with that of the steam admitted to the cylinder, which is always in excess of that which enters the condenser, the difference being reduced to water in the cylinder. In practice the value of a vacuum will be less than 55,799 foot-pounds, by the back pressure in the exhaust pipe, which is seldom less than 2 lb. The value of each pound of steam condensed with this deduction is $1828·8 \times 26·36 = 48{,}207·168$ foot-pounds. Neglecting fractions, for each pound of steam blown into the atmosphere, therefore, in a non-condensing engine, we lose 48,207 foot pounds, or 62·3 heat units. Let us turn now to a pound of steam at, say, 100 lb. absolute pressure admitted into the cylinder of a good engine, and worked expansively to the best advantage. This pound of steam will develop 150,000 foot-pounds of work, and will utilize as much as 195 units. For every pound of steam of the stated pressure condensed in the cylinder at the beginning of the stroke we lose then 150,000 foot-pounds of work. Now, roughly speaking, 150,000 bears to 48,207 the proportion of three to one, consequently our readers will perceive, if they have followed us so far, that the condensation of 1 lb. of steam in the cylinder will more than neutralize all that can be gained by the condensation of 3 lb. of steam in the condenser. To put this in a slightly different form: let it be supposed that an engine working without a condenser had no cylinder liquefaction, but that when working with a condenser, 1 lb. of steam was condensed in the cylinder for every 3 lb. condensed in the legitimate place—the condenser; then would the use of a condenser make that engine less economical than it was before; for the loss by cylinder condensation would be 150,000 foot-pounds, while the gain due to the vacuum would be but $48{,}207 \times 3 = 144{,}621$ lb. It may be urged that steam cannot give out 150,000 foot-pounds of work without a condenser under practical working conditions. This we are willing to admit. This does not affect our argument in any way. In a condensing engine each pound of steam condensed in the cylinder represents a loss which will more than balance what can be gained by the condensation of three times as much steam to produce a vacuum. The work done by a pound of steam in a non-condensing engine may be taken as $150{,}000 - 48{,}207 = 101{,}793$ lb., and each pound of steam condenser in the cylinder will represent an equivalent loss. We can now proceed to consider the conditions under which a condenser will do more harm than good more closely. Let us assume that we have two engines, one condensing, the other non-condensing, and each working under such conditions that in the condensing engine each pound of steam shall do 150,000 foot pounds of work, while in the non-condensing engine each pound of steam shall do 101,000 foot-pounds of work—then the first engine will require per horse power per hour 13·14 lb. of steam, and the non-condensing engine will require 19·6 lb. of steam; that is to say, the condensing engine will use about two-thirds as much steam as the non-condensing engine. But it is well known that in practice both engines would use much more steam than the quantity given above. The difference between the theoretical and the actual quantity is mainly disposed of by condensation in the cylinder. Let us now suppose that the condensation in the cylinder of the condensing engine is three times as great as it is in that of the non-condensing engine, and see what will follow. It is a very good engine which gets on with 20 lb. of steam per horse per hour; subtracting 13·14 lb. from this, we have 6·86 lb. per horse power per hour liquefied in the cylinder. If one-third of this, say, 2·25 lb., is liquefied in the non-condensing engine, then we have for the condensing engine a consumption of 20 lb. of steam per horse power per hour, and for the non-condensing engine a consumption of $19·6 + 2·25 = 21·85$ lb., and the gain due to the presence of the condenser is thus under 2 lb. of steam per horse per hour, or say, 0·2 lb. of coal, which would hardly pay for the extra cost of the condenser and its appurtenances.

To make the comparison quite fair, we shall put it in yet another point of view. We have seen that every pound of steam in a non-condensing engine will do 101,000 foot-pounds of work, while the condensation of a pound of steam will do 48,000 foot-pounds, in round numbers. Now, by adding a condenser to a non-condensing engine, we apparently augment its economical efficiency by nearly 48 per cent. Let it be supposed, however, that for every 3 lb. of steam condensed in the condenser, 1 lb. of steam is condensed in the engine which was not so condensed before, and it is clear that the whole advantage of the vacuum is swept away at one stroke. Each pound of steam so killed represents, as we have shown, 150,000 foot-pounds, while each pound of steam employed to make a vacuum represents but 48,000 foot-pounds. It only remains to be considered whether, under any circumstances, condensing engines do or do not condense in their cylinders more than one-third of all the steam passing through them. Of this we have no manner of doubt. A condensing engine which we tested not long since, when working up to about 200-horse power, was expanding 95 lb. steam—absolute—fifteen times, and using 26 lb. of steam per horse power per hour. The cylinder was well jacketed; the piston and valves quite tight. By the indicator this engine would not have required more than 13 lb. of steam per horse per hour. To all appearance the steam delivered from the boiler was quite dry and free from priming; but assuming that as much as 2 lb. of water in 26 lb. passed over as insensible priming, and allowing for the influence of clearance, we have still the fact that much more than one-third of all the steam which entered the engine was condensed in the cylinder. If by taking away the condenser this loss could have been reduced, the immediate result would have been that every pound of steam saved from cylinder condensation would have done as much good as 3 lb. making a vacuum. The total quantity condensed in the cylinder was, say, 11 lb. per horse per hour. This represents as much work as could be got by the condensation of 33 lb. of steam, but the whole gain to be had from the condenser was that due to the condensation of 13 lb. of steam; and if this entailed the destruction in the cylinder of 4 lb. of steam then the condenser did more harm than good. With or without it the consumption of steam would still have been about 26 lb. per horse per hour, while if the extra condensation due to the presence of the condenser had reached 5 lb. per horse per hour, the engine would have been more economical if worked non-condensing.

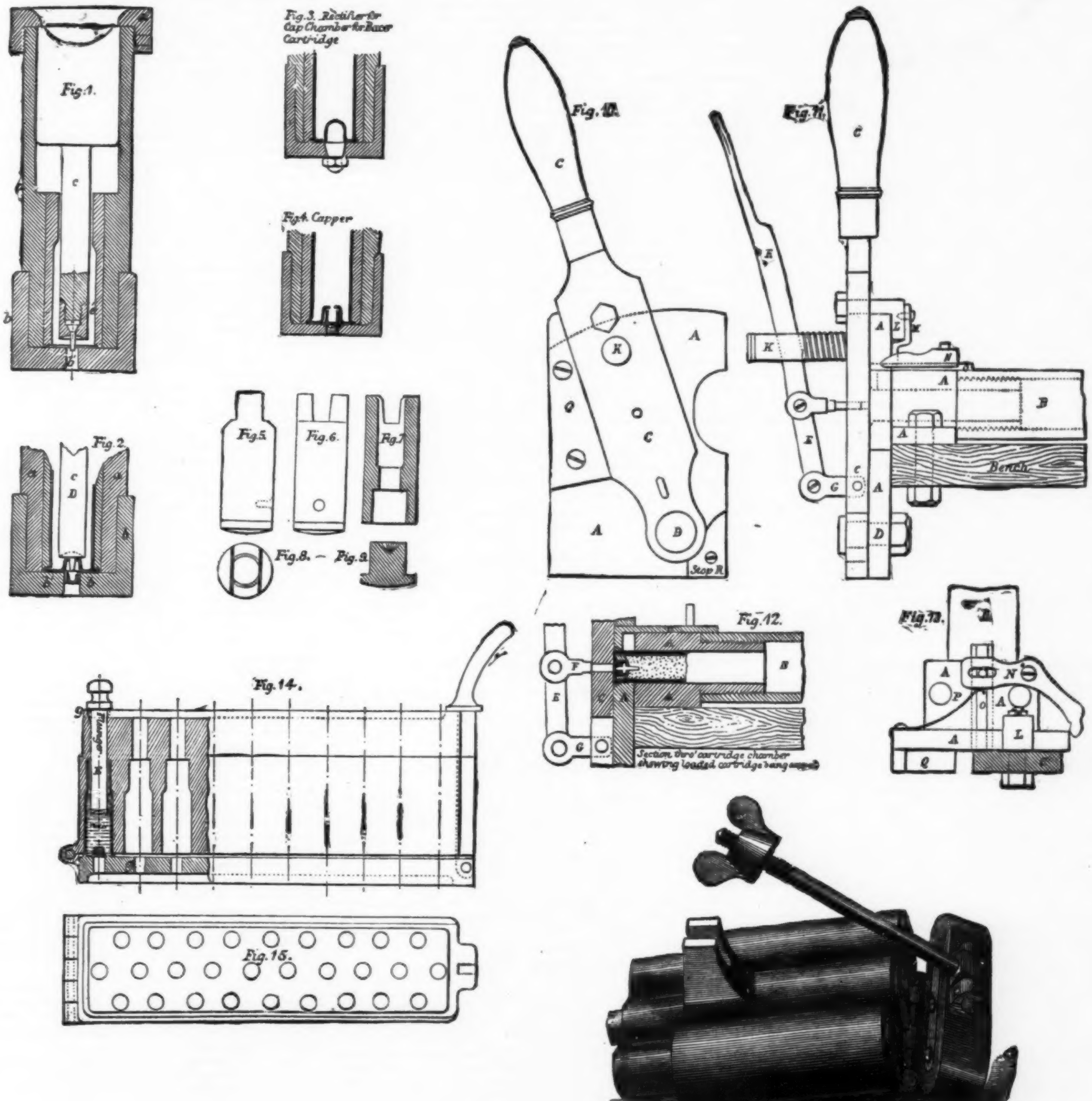
We venture to think that it is hardly necessary to explain here at any length that the destruction of steam in a condensing engine must be greater than it is in a non-condensing engine. We have repeatedly explained the nature of the frigorific influence exerted by the condenser. We can cite here, however, a very simple and pretty experiment which will illustrate it. If one of the bulbs of the glass toy known as a cryophorus be immersed in a mixture of snow and salt, the water in the other bulb will begin to boil violently as soon as it is relieved from pressure by the condensation of vapor in the first bulb. It will thus part rapidly with its latent heat, and will freeze. In the same way

vapor rapidly conducts heat to the condenser, chilling the inside of the cylinder and passages. In order that a condenser may be used with advantage, care must be taken that it shall not cause excessive cylinder condensation, and this is best done by using means to keep the cylinder quite dry inside; drain cocks should always be fitted at the lowest point, and whenever it is possible the steam ought to be moderately superheated. When, on the contrary, a cylinder is unjacketed, and, perhaps, unlagged; is badly drained, and so large that high measures of expansion must be employed to prevent it from running away with its load, then will the condenser be productive of positive waste of fuel. In other and more favorable cases it will do neither good nor harm. In all cases its value falls far below that theoretically appertaining to it.—*The Engineer.*

UTILIZATION OF CARTRIDGE SHELLS.

One of the most important portions of the ammunition for breech-loading small arms is the brass case which receives the powder charge, and carries at its base the percussion cap, the upper end of the case embracing the lower part of the bullet. In the United States, and several other countries where common sense is superior to conservatism and routine, the cartridge cases are of solid drawn brass, and are as truly made as any part of the rifle mechanism. We believe that the Duke of Cambridge has been always in favor of this and other obvious and sensible economies, but the War Office authorities unfortunately are not so far advanced as to entertain the abandonment of antique and time-honored regulation patterns, and consequently the comparatively ill-made and clumsy Boxer cartridge continues, and probably for a long while will continue, to be the type of our small arms ammunition. It is evident that the cost of the brass cartridge, whether it be well or ill-made, is very considerable, and taking into consideration the millions of rounds which are fired even in times of peace, and the indefinitely larger number in times of war, the loss in wasted cartridge cases represents annually a very large sum, and the advantages which would accrue from the re-use of the cases would be very substantial; indeed, it has happened on many occasions that if any simple appliance had been available by which cases that had been fired could be rapidly and quickly made up again into serviceable rounds, our troops would have been relieved from critical and dangerous positions, and would have been able to have pushed forward advantages which shortness of ammunition prevented them from doing. So convinced is the Indian Government of the necessity of supplying troops with such facilities when campaigning, and of the economy of doing so when in cantonment, that it has adopted the extremely efficient and simple devices designed by Mr. Richard Morris, of the Scinde, Punjab, and Delhi Railway, Lahore, which we illustrate on the present page. The operations to be performed on the fired and distorted cartridge case are: 1. To remove the spent cap. 2. To restore the case to its proper form, including the recess in the base of the case within which the cap is placed. 3. To recap the cartridge either before or after loading. In connection with these processes there are several modifications to be mentioned in their proper place, chiefly depending upon whether the cartridges are blanks or provided with bullets. For restoring the case to its proper dimensions after it has been distorted by firing, it is placed in a former, made as shown in Fig. 1. This former, or die, consists of a cylindrical body, *a*, containing a metal liner bored out to the proper size and form of a case, the upper part being bored out cylindrically to a somewhat larger diameter, as shown. Over the top of the body is screwed a cap, a^1, with an opening in the middle, and the lower part fits into a base, *b*, in the bottom of which is a small opening, b^1. Sliding within the body, *a*, of the die is a plunger, *c*, the head of which is enlarged so as to fit the upper part of the bore in the die, and the top of this head is dished hemispherically, as indicated by dotted lines. The former, or die, is used as follows: The base, *b*, is fixed in a solid block of wood which has a hole in its center. A distorted cartridge case is then placed in the die, and the head or cap is struck with the flat face of a cooper hammer until the body of the die is driven home to the bottom of the base, *c*. This operation reshapes the cartridge case. The plunger, *c*, is then struck with the pointed head or nose of the hammer, which ejects the cartridge case from the die. The head of the plunger is hollowed in order that the effect of the blow with the hammer may be centralized, and any tendency to jam or strain the plunger obviated. The same operation also effects the removal of the useless cap by means of a small needle punch attached to the bottom of the plunger as shown in the drawings, where e^1 is the punch made with an enlarged head, which rests against the flat end of a screwed projection on the plunger, and over which a screwed cap passes, holding the punch in place. The same device is also used for recapping in such cases where it is desired that this operation should precede that of charging. The uncapping needle having been removed, a small stud (Fig. 2) is inserted in the hole of the cap, *b*, the inner face of the stud being made concave to approximate to the form of the head of the cap; the case is then replaced in the die, *a*, with the cap, an anvil, as shown, is inserted in the cap chamber, and the plunger, *c*, is placed with its lower end bearing on the base of the cartridge case; the die is then driven home, and the cap thereby forced into place. It will be noticed that the plunger for this operation is hollowed out at the bottom in such a way as to allow of the entry of the cap chamber and the projecting part of the anvil, so that the process of recapping effects, at the same time, the removal of any distortion that the cap chamber may have received by the previous discharge. If from the same cause the flashing passage in the chamber, which allows the flash from the cap to pass to the powder, has been affected, it can be reduced by means of a suitable former attached to the end of the plunger, or the bottom of the latter may be capped to answer the same purpose; this arrangement is shown in Figs. 3 and 4.

Where, as is usual with ball cartridges, it is desired to insert the caps as a final operation, the apparatus shown in Figs. 10 to 13 is employed. It consists of a die, A, the interior of which is bored out so as exactly to fit the cartridge, and to it is screwed a tube, B, of any desired length; this tube acts as a safety device, and the end of it is pointed in any desired direction, so that if during the operation of capping a cartridge should accidentally explode, the bullet may be fired into a sand heap, or be otherwise rendered harmless. A plate, A^1, is attached to the face of the die, of the form shown in Fig. 10, and having two stops, Q and R. Pivoted to this plate at D is the lever, C, which can be moved to and fro between the stops, Q and R. Fixed to C is the spring lever, E, held away from C by the spiral spring placed around the slotted stud in which E is free to move to and fro. Jointed to the lever, E, is a plunger, F, entering a hole in the lever, C, and able to move to and fro by pressing the finger plate



MORRIS' APPARATUS FOR UTILIZING CARTRIDGE SHELLS.

of E. When the lever, C, is thrown over to its lowest position against the stop, R, the hole in which the plunger works is accessible and a cap is inserted in it in front of the plunger; on throwing the lever over to its position, Q, the cap is brought immediately opposite the cap chamber of the cartridge contained in the die, A, and by pressing the lever, E, the cap is forced by the plunger into its proper position. The cartridge is extracted by means of the mechanism shown on the drawings. On the top of the die is the extractor bar, O, connected by a vertical pin to the horizontal lever, N, the pin passing through a slot in the lever as shown; the lever is jointed to the top of the die block as shown in Fig. 13. Fastened to the lever, C, and fitting over the curved top of the plate, A, is a block, L, to which a bent tongue, M, free to move in one direction only, is hung by a pin. On throwing over the lever, C, to its position, R, the tongue strikes the curved end of the lever, N, and throws the opposite end forward, and with it the extractor and cartridge. But on the return movement the tongue, M, which is then free to swing, passes over the end of the lever, which is thrown back to its normal position by the spring, P. This extremely neat and ingenious device occupies but a small space and can be instantly clamped on to a table, or any convenient place.

One of the most interesting features of Mr. Morris's invention remains to be noticed. It is the hydraulic uncapping arrangement, and is illustrated by Figs. 14, 15, and 16. Figs. 14 and 15 show a form specially adapted for military purposes. It consists of a block, G, with a number of holes bored in it to fit the cases. Hinged to the bottom of the block is a tight fitting cover, g^1, recessed opposite the holes to receive the base of the cartridge, while openings are also formed through the block corresponding to the axes of the cartridge cases; a raised lip is formed round the top of the block. The cartridge cases are then filled with water, and a short plunger fitted at the lower end with a cup leather is inserted in each case successively and struck smartly with a hammer, the result being that the blow is transmitted through the water with sufficient power to drive out the cap, which falls through the opening in the plate, g^1. The same arrangement can be used for recapping by inserting a cap through each of the holes in the cover, and pressing them home by a capping plug or pin.

A modification of this device adapted to sporting cases is shown in Fig. 16. Here a group of three receivers is cast in one block, the hinged bottom being held in place by the screw and nut bearing on the projection formed on one side of the central receiver. The inside of the bottom plate is recessed, and three holes are formed in it to allow of the escape of the old caps, while the loose piece with three concave studs can be fitted into the recess to serve as abutments when recapping. The whole of the appliances we have described are remarkable for their compactness, simplicity, and efficiency, and it requires little consideration to understand their great usefulness and the economy which can by their means be effected. With a very slight training any soldier can become proficient in these various rapid processes of utilizing cartridge cases which are now useless, and we have no doubt that the apparatus ought to form a part of the equipment of every regiment, and the knowledge of employing it a necessary portion of the education of as many men as may be sufficient to replenish the empty cartridge cases.

A few figures will serve to give an idea of the saving that may be effected in this direction. The average number of rounds of ball cartridge supplied to the infantry of the regular army and to volunteers, is 100 per man; to the militia, 20. Taking the numbers of their forces to be approximately as follows:

Regulars,	80,000,	total rounds per annum,	8,000,000
Volunteers,	200,000	" " "	20,000,0 0
Militia,	139,000	" " "	2,780,000
			30,780,000

The cost of the blank cartridges is £1 2s. 10d. per 1,000, of which 4s. 2d. is for powder, 2s. for caps, and 2s. for loading, leaving 14s. 8d. as the cost of the cases per 1,000. The ball cartridges, of course, cost more, since the case is more expensive and the projectile has also to be added. But assuming that the 30,000,000 rounds of ball cartridge annually fired for practice and exercise were collected and reloaded, and allowing a cost of 2s. per 1,000 for their collection, the expense of reproducing them as blank cartridges would be 10s. 2d. per 1,000, showing a clear saving of 12s. 8d. per 1,000, or £19,000 a year. Of course so large a quantity of blanks would not be required, but the cases could be made up as ball cartridges without any difference in the economy effected, and this saving would in one year pay for the cost of the apparatus three times over. At present none of our colonies possess the means of making up breech-loading ammunition, but are all dependent upon Woolwich for their supplies. By the use of this apparatus, together with bullet making machinery, which is inexpensive and easily worked, and caps, of which an unlimited number can be kept in store, every colonial government may be made at all events ten times as independent of this class of war material as they are at present, provided the solid brass cartridge can be introduced, as it must be one day, for this can be reloaded ten times without injury. We may mention that the apparatus we have described is manufactured by Messrs. Middleton & Co., of Southwark, London, and Messrs. Greenwood & Batley, of Leeds.—*Engineering.*

THE SOCIETY OF ENGINEERS.

PRESIDENT'S ADDRESS.

THE first ordinary meeting of the Society of Engineers for the present year was held on Feb. 7, in the Society's Hall, Victoria street, Westminster, London. After thanking the members for having elected him to the chair, the President reviewed the proceedings of the society for the past year, noticing and commenting upon the various papers read during the session, and the visits made during the vacation. He observed that there had been seven papers read and well discussed, each subject being of practical importance to the profession. Visits had been made to five different works, every one of which was of engineering interest. Some belonged to the government, and other to companies and private firms, and to each of the proprietors alike the thanks of the society were due for the valuable opportunities of instruction afforded, especially to the junior members of the profession. The general position of the society, he observed, was very satisfactory, a considerable number of members having been elected during the past year, and the accounts, which had just been read, showing a good balance in hand, and indicating generally a healthy condition of the society's affairs.

Turning to matters of more general interest, the President next reviewed the recent progress of applied science in various departments. Referring to the manufacture of iron, he made the following observations: Competition in this and other countries, through the opening out by new railways of fresh iron and coal measures, and in consequence of every one endeavoring to do more than his neighbor, and to reduce the cost of smelting iron to the lowest amount, has, I fear, in many instances not contributed to the improvement in the quality of iron. The lives of blast furnaces are of very short duration, compared with what they were in the early part of the present century.

I can give two instances of the length of time furnaces lasted without being blown out, and which furnaces were at the Alfreton Ironworks, Derbyshire. One blown in during the year 1812 was in blast until 1873, while another blown in during 1821 was not blown out until 1866. This latter furnace was visited by the members of the British Association during their meeting at Nottingham. After the furnace was blown out, an examination showed that there had been formed a partial lining of plumbago which protected the fire-brick lining, which I think you will admit was a very remarkable incident in blast furnace practice.

I do not find charcoal had been used in smelting during the earlier period of the life of these furnaces. Coke alone was used up to 1829, when equal parts of coal and coke were substituted. The introduction of the hot blast was the cause of all coal being used; at that time the furnace or Tipton coal mixed with a lower hard coal was the fuel used. The ironstone used was the argillaceous of the coal series, containing from 25 to 37 per cent. of metallic iron. The iron in the raw stone exists as a carbonate, and requires calcining at a cherry red heat, to convert the carbonate into a peroxide of iron for melting. Iron made from this ore is very strong indeed. The bands of ironstone, technically called "rakes," are some of them found with the coal seams; the blue rake lies above the lower hard coal; the kernel rake lies above the hard coal. Nine different rakes have been worked at the Alfreton Ironworks, and it was found that the greater the variety used, the better and stronger was the iron produced; I find Durham coke the best for smelting purposes. The demand for iron being greater, and the oolitic formation being used, ironmaking took a new form. Blast furnaces were constructed to produce very large quantities of pig iron, and works were erected for the purpose of using the oolitic ores alone. In consequence of not having any of the old strong argillaceous ores mixed with them, iron sometimes gets into bad repute, and makers of strong iron are sometimes to their disadvantage classed with others who do not so mix the iron ores. I find also that the hard coal of Derbyshire gives the iron a better quality than coke as used in the north. Furnaces using coal do not require to be built more than fifty feet high, but those using coke are best at seventy feet or upwards.

Low furnaces are undoubtedly the best for the iron ores lying in the Midland counties, and are about 48 ft. high, 3 in. to 3½ in. tuyeres, pressure of blast, 4 lb. to 4½ lb., and blast heated to about 750 deg. A furnace of this description makes a good tenacious iron, from a mixture of ores from Lincolnshire, Leicestershire, Northamptonshire, and the argillaceous ore of Derbyshire, and smelted with the best hard coal, clean and free from pyrites.

Re-melting iron in the cupola should be very carefully performed. The iron should consist of a mixture of three or four kinds of pig, and the coke should be very clean and free from sulphur, or, however good the pig iron may be, the re-melting will ruin the iron; make it tender, and it will not sustain nearly the strain it should do, hence some of the best founders do not sell pig iron.

The metal from the blast furnaces requires testing every day, and if the re-melting be carefully carried out, and the castings allowed to remain in the sand long enough to prevent them being chilled, there need then be no fear of the iron not standing the required test, which generally is as follows: That a bar of 1 in. square and 38 in. long, and weighing not more than 10 lb., will, when supported at points 36 in. apart and loaded in the middle, sustain a weight of not less than 7 cwt.

I think it would be well for every one entering our profession to go first for a time into a foundry and see for himself the varying contraction which goes on in different kinds of iron; afterwards he should go into the pattern shop. He would afterwards remember to design his work so that the iron should contract as far as possible uniformly, and so that one part should not fracture another during cooling, which is very often the case. I think, too, that engineers are often asked to produce a certain amount of work, and the cost not to exceed a certain sum. This causes the thicknesses of metal to be so cut down that it really is a wonder there are not more accidents than there are.

I may observe in passing that the cost of pig iron has been greatly reduced by the gases being taken from the furnaces for heating the air in the hot-blast stoves, and also for the blowing engine steam boilers, and for other purposes connected with iron manufacture. This saving in coal in pig iron making, also in the foundry, and the enormous saving of fuel in steel making, is to a great extent the cause of the increasing surplus of coal throughout the country. Mr. Hunt's figures show that the average quantities of coal consumed have declined since 1871 to the extent of 16 cwt. per ton of pig iron made in the United Kingdom. As the annual make of pig is almost 6,000,000 tons, the total economy is about 4,800,000 tons per annum.

Another saving occurs in the manufacture of steel rails by the Bessemer process, the quantity of coal required to produce a ton of such rails being generally admitted to be 65 per cent. less than required for iron rails. The annual production of steel rails is about 650,000 tons, so that we have a reduced consumption of fuel of about 1,166,500 tons, as compared with iron rails. There are also other departments of iron making in which the consumption of solid fuel has been greatly reduced of late years by the use of the waste gases from the furnaces as well as by improved methods of workings.

The President then reviewed the progress of electric lighting, briefly describing the various systems which stood foremost in practice, and pointing out their advantages. He then referred to the development of gas illumination, which had been greatly improved since the introduction of electric lighting in our streets, the two leading systems of advanced public illumination being those of Sugg and Bray. He then described Pintsch's system of railway carriage lighting as working on most continental railways and on many of our own. The advances made in steam engineering then received attention at the President's hands. He adduced, as an instance of high pressures and economical working, the little steam yacht Anthracite. The progress made in working engines by means of compressed air was illustrated by a reference to the Beaumont system, which we may shortly expect to see in practical use for railway and tramway purposes. Bower's beautiful process for protecting iron by a coating of magnetic oxide was then explained, the President, in conclusion, describing the photophone, which he instanced as another beautiful outcome of scientific research. He observed that, although of no practical value at the present moment, the time might arrive when it would be before the world as an instrument of practical utility adapted to the every-day wants of man. The address, which was very interesting, was attentively listened to by an appreciative audience, and at its close a cordial vote of thanks was given to the President, who acknowledged the same in a few appropriate words, and the proceedings terminated.

AN IMPROVED FILTERING APPARATUS.*

By MR. HENRY CHAPMAN.

THE main cause of the present difficulties experienced in the disposal of the sewage of large towns is the failure to obtain an economic system of pure filtration for such enormous volumes of liquid. This is proved by the fact that, out of the numerous filtering processes, both mechanical and chemical, that have been tried, not one has been generally adopted; and even such important centers of civilization as London and Paris continue to have their rivers polluted and the health of their inhabitants injuriously affected by the unfiltered sewage.

The reason of the failure of the various mechanical processes is easy of explanation. In all mechanical filters, whether by canvas disks, bags, cloths, or sand, or other granular beds, the impure liquid is pressed against a porous material, the surface of which should be sufficiently fine to arrest the solid impurities, and allow only the pure liquid to pass away. When these solid impurities are of a slimy nature, as in sewage, their deposit on the filtering surface quickly becomes so impervious that the liquid is prevented from passing through the deposit to the filtering surface, even though great pressure be employed. The operation consequently comes soon to an end, and cannot be resumed until this deposit has been removed.

Owing to these repeated stoppages at short intervals for cleansing, such an immense amount of manual labor, and such a large number of spare machines, or cloths, or filtering beds, are required, to filter the sewage, even of a small town, as render the cost of filtration quite disproportionate to the advantages to be obtained by it.

It is, therefore, evident that for a system of filtration to be successfully employed, in an economic point of view, for sewage, it is absolutely necessary that these frequent stoppages be avoided.

The principle of the Farquhar filter is that of the continuous removal of the solid or slimy matters held in suspension in the liquids to be filtered, as they become deposited on the surface of a filter-bed, during the process of filtration. The surface being thus continually freed from obstruction, rapid and continuous filtration is obtained.

Description of the Machine and Process.—The filter-bed, which is composed of sawdust, or sand, or powdered cinders, or other suitable granular material, is contained in the closed cylinder, W, Fig. 1 (see next page), and rests upon a coarse canvas or cloth, which is supported by a perforated plate resting on a strong grating, U.

The liquid is forced into the filter at the nozzle, A, and passes through the hollow screw spindle, B, direct to the underside of the cutter-plate, S, where it is distributed uniformly through the channels, C, on to the surface of the filter-bed. The filtered liquid passes through the filter-bed, leaving all its solid impurities on the surface of the bed, and finally issues from the pipe, X.

During the process of filtration, the cutter-plate, S, is made to revolve by means of the pulley, L, and the bevel gearing attached, and when desired is caused to descend at any speed required, irrespective of its speed of revolution, by means of the feed motion, F G, as shown.

In some cases the solid matters held in suspension in the liquid to be filtered are of a chalky nature, a thin deposit of which forms of itself a good filtering medium. In these cases it is only necessary to revolve the cutter-plate continually over the surface of the filter bed in the cylinder, W, and not to cause it to descend. The accumulating deposit will then be continually scraped off and forced up the inclined plane of the knife, K, on to the top surface of the cutter-plate, S, the under surface of which will thus always be kept free; and the supply of liquid will be continually in direct contact with the surface of the filter-bed.

In other cases the solid matters held in suspension in the liquid to be filtered are of a slimy nature, a thin deposit of which, if left on the surface of the filter bed, would stop the filtration. In these cases it is necessary to cause the cutter to descend as well as to revolve, so that at each revolution of the cutter a very thin layer of the granular filter-bed will be cut up and scraped off; together with the slimy deposit adhering to it, thus producing at each revolution of the cutter a clean filtering surface on the filter-bed, and practically starting a new filter.

The speeds of the revolving and descending motions of the cutter-plate are determined by the amount of deposit required to be removed from off the surface of the filter-bed in a certain time.

When the cutter plate has descended to within two inches or three inches from the bottom of the filter-bed, the descending motion of the cutter-plate stops automatically. The operation is then at an end, and the filter-bed, which at the commencement of the operation was underneath the cutter-plate, will now be at the top of the cutter-plate, and intimately mixed with the solid impurities which it has arrested. If desired, the liquid remaining in the filter-bed at the end of the operation can be expelled at the pipe, X, by means of compressed air forced into the filter through the center pipe, B.

To remove the fouled filter bed, it is necessary first to unbolt the cover, Q, and to raise it to the dotted lines, as shown. Then, by means of the reversing gear, K, the cutter-plate, which may have taken many hours, or several days, to descend to the bottom of the filter-bed, can be made to revolve in a contrary direction, when it will quickly ascend the full pitch of the screw at each revolution, and the fouled filter bed will, in a few minutes only, be automatically discharged over the top of the cylinder, W. Both the cutter-plate and the cover, Q, are then raised to a suitable height above the cylinder, W, as shown by dotted lines, so as to allow the cylinder being cleansed, and a fresh filter-bed being placed therein ready for another process. The whole of the above operation for a large machine should not exceed one hour.

From the above it will be seen clearly that each time the cutter or scraper of the cutter-plate removes the solid impurities, and thereby frees the surface of the filter-bed from

* Paper read before the Institution of Mechanical Engineers.

the impurities which would otherwise choke the filter and stop the filtration, a fresh filter is, to all intents and purposes, created. Thus it is evident that the removal of a thousand choked filtering surfaces during one continuous process is practically the creation of a thousand fresh clean filters.

Results of Working.—The length of time during which one filter-bed continues to filter depends upon the amount and nature of the solid impurities held in the liquid and the depth of the filter-bed. The pressure required in the liquid also depends upon its nature, and upon the speed of filtration desired. On these points the following summary of experiments made in France will furnish a safe guide for calculations.

The size of the filter-bed used during these experiments was only 25 centimeters (9⅞ inches) in diameter, and 25 centimeters in depth.

1. At Les Jardins d'Essai des Travaux de Paris, Asnières, near Paris, experiments were made, August 27, 1880, in the presence of M. Buffet, Ingenieur-en-chef des Ponts et Chaussées, and of Messrs. Durand-Claye and Locquet. The "eau des égouts," or town sewage, was filtered perfectly bright and continuously at an average speed of 6·25 liters (1·375 gallon) per minute, with a pressure of liquid equal to one atmosphere. When the pressure was increased to 1½ atmosphere, the speed was 8 liters (1·761 gallon) per minute.

2. At the Dépotoir des Travaux de Paris, La Villette, Paris, experiments were made on October 7, 1880, in the presence of M. Duval, manager of the dépotoir, and his assistants. On this occasion the "eau-vanne," or night-soil, was filtered perfectly bright and continuously at the rate of 1·50 liters per minute, with a pressure equal to one atmosphere.

This is admitted to be the most difficult of all liquids to filter. It has never been filtered continuously, previous to the above experiment, and its filtration is one of the burning questions of the day on the continent. It was then proved, to the satisfaction of the engineers and officials appointed by the French Government to superintend these experiments, that the machine was capable of separating the solids from the fluids, and that satisfactory filtration was obtained, as shown by the samples taken, which are now in the laboratory of the Ponts et Chaussées.

And further, MM. Duval and Durand-Claye state, with reference to the experiment on the "eaux-vannes," that, "at the beginning of the operation the filtering bed was twenty-five centimeters deep, and at the end was only seventy-five millimeters (3 inches) deep, and *the liquid still passed out clear.*"

In order to demonstrate practically, before the officials, the great advantage of the continual removal of the choked surfaces, the rotary motion of the cutter-plate was stopped in the middle of the above experiments, and the knife on the cutter-plate consequently ceased to scrape off and remove the impurities from the surface. Directly this took place the filtration rapidly diminished in volume, and in a few minutes it was totally arrested, though the pressure of liquid on the filter bed was maintained the same. The cutter-plate was then made again to revolve, and as soon as the choked surface was cut off and forced up the knife on to the top surface of the cutter-plate, the filtration took place as rapidly as at the beginning of the experiment.

3. At the sugar works of the Compagnie de Fives-Lille, at Coulommiers, experiments were made in the presence of M. H. Pellet, chemist to the Compagnie de Fives-Lille, and of the manager and engineers of the works. Beet sugar juice was filtered perfectly bright and continuously by the model machine, with bed 9⅞ inches deep, at the rate of eight liters (1·761 gallon) per minute, with a pressure of liquid equal to two atmospheres. The filtration was continued for the space of four hours, and could have been continued for four hours longer, without changing the filter-bed or arresting the process, had it been desired.

The filtration was pronounced by the chemist, M. Pellet, to be perfectly pure, in fact, as pure as if it had been filtered through blotting paper, and much better than the average filtration obtained from their ordinary press filters. M. Pellet also stated that he saw no reason why a machine could not be constructed to filter continuously for four days. Their ordinary press filters act for only two and a half hours, after which they have to be taken to pieces.

The Compagnie de Fives-Lille, who have acquired the right to manufacture these machines in France, are now constructing a large apparatus.

4. River water having clay and slimy matters in suspension, such as choke up all ordinary filters, is filtered perfectly bright and continuously by the model machine, having a filtering area of only 25 centimeters (9⅞ inches) diameter, at a rate exceeding 10 liters, or 2·20 gallons, per minute, under a pressure of one atmosphere only. Under a pressure of two atmospheres, the speed of filtration would no doubt be greatly increased.

Applications. Sewage.—In this country there is no such difficult liquid to filter as the "eaux-vannes," which, according to French government engineers, contain about 100 per cent. more of solid matter than the ordinary sewage here. For this difficult liquid, and also for sewage, ordinary sawdust is found to be the best material of which to compose the filter-beds. Owing to its light, elastic, and absorbent nature, it readily takes up and retains about eight times its own weight of the impurities arrested. It is very cheap, easily obtainable in large quantities, and, when surcharged with sewage matter, forms a valuable manure. It is, however, by no means necessary to the process that sawdust only should be used. If desired, powdered cinders or fine sand, both of which are valuable for clay lands, especially when mixed in the solid sewage, can be employed.

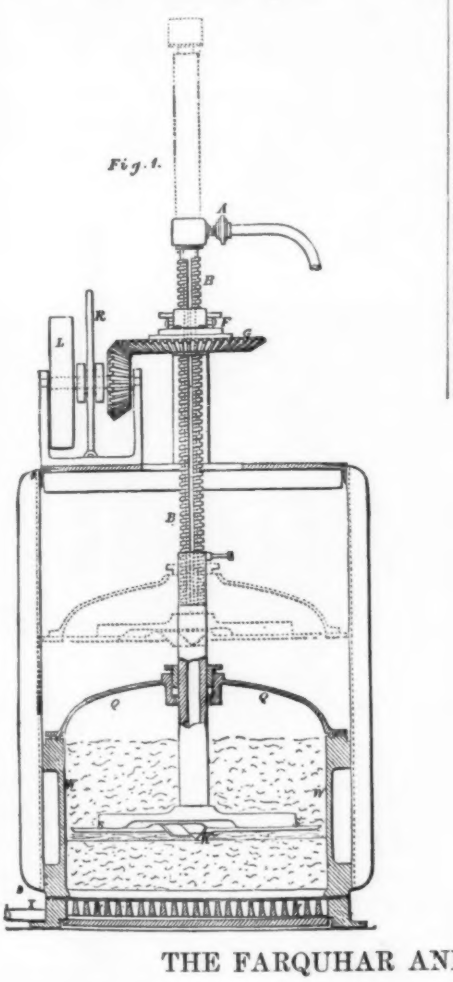
In the experiment at Asnières before mentioned, the sewage was filtered in the same black state as it came direct from the main sewers of Paris; but before filtering the "eaux-vannes" it was found advisable to mix a small quantity (only 3 per cent.) of lime with the thick, slimy liquid previous to filtration, as thereby greater speed was obtained than when filtered in its natural condition.

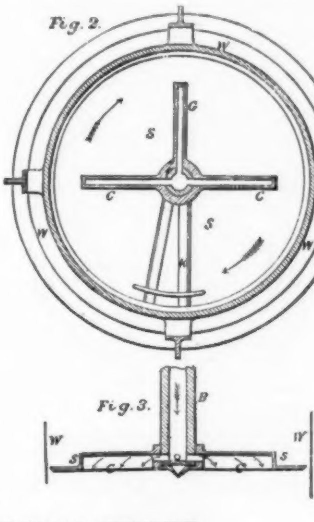
A very important advantage of this process for sewage is the solid condition, at the end of the operation, of the residuum absorbed by the filter-bed. If, at the end of the operation, the balance of liquid in the bed is expelled, by means of compressed air introduced into the cylinder through the hollow screw spindle, previous to taking off the cover, the filter-bed and residuum form together a solid, and of course valuable, cake of manure, ready to be at once conveyed by road or rail to any part of the country, without having previously to undergo a drying process, with its great expense and serious objection in a sanitary point of view.

The cost of filtration of the sewage of towns by this process should be *nil*, as it is computed that it will be fully covered by the price to be obtained from the sale of the sewage cake as manure. The speed of filtration, by the model machine, of the sewage at Asnières before referred to, was 8 liters, or say 1·761 gallon per minute, through an area of 9⅞ in. diameter. Therefore the speed through one square foot of area is 3·31 gallons per minute, and an apparatus 10 ft. in diameter would filter 260 gallons per minute, or say 374,400 gallons per day of 24 hours. As the time occupied between the stopping of one operation and the commencement of another, after emptying of the filter and renewal of the bed, should not exceed one hour, it will be easy to estimate the number of machines that would be required to filter any given quantity of sewage to be operated on per diem.

Waterworks.—For this purpose this apparatus will prove of great value. First, from an economic point of view, the large filtering areas now employed, together with the necessary spare filter beds, all of which occupy much valuable land, would be dispensed with. Secondly, from a sanitary point of view, the water would not be exposed in large surfaces to the unhealthy action of the atmosphere in or near large and densely populated cities. Lastly and chiefly, the filtration by this process has been proved to be much purer than anything obtained by the ordinary process of filtration; in fact, again to quote the words of M. Pellet, "the filtration was as pure as if it had been filtered through blotting paper," which is the recognized test of pure filtration.

In all the experiments referred to, after the filtration was finished, samples of the filter bed were carefully taken, and it was found, in each case, that the portion of the filter bed which had been cut up during the process of filtration was intimately mixed with the solid and slimy matters which it had arrested. Also that the portion of the filter bed which had not been cut up was perfectly clean throughout, with the exception of its top surface only, which was coated with a thin deposit of the solid impurities; thus proving, beyond doubt, that the solid impurities did not penetrate below the surface of the filter bed,





THE FARQUHAR AND OLDHAM FILTER.

With a view to give some comparison between the cost of filtration with this process and with that employed by the metropolitan water companies, the following extract from one of the official reports may be taken as a guide:

AVERAGE RATE OF FILTRATION PER SQUARE FOOT OF AREA PER HOUR.

New River Company	2⅛	gallons.
East London Company	1⅓	"
Southwark and Vauxhall Company	1⅛	"
West Middlesex Company	1¼	"
Grand Junction Company	2⅜	"
Lambeth Company	4	"
Chelsea Company	2	"

From the above it will be seen that the average rate of filtration is approximately 2 gallons per square foot per hour.

Taking the speed of filtration by the model machine (as before referred to) at 10 liters per minute, with a pressure of one atmosphere only, through a filtering area of 25 centimeters diameter, the quantity per square foot area would be 18·8 liters, or say 4⅛ gallons per minute, or 247½ gallons per hour, as against 2 gallons per hour by the ordinary process now employed. From this calculation it follows that one machine 10 ft. in diameter should filter 466,560 gallons per day of 24 hours.

The construction of the machine being exceedingly simple, the cost should not form a large item, and for the same reason the cost of maintenance should bear but a small proportion to the amount of work done. The feed of filtration in this machine is always constant, and no difficulty should be experienced in filtering waters containing fish-spawn or clay matter in suspension; whereas in the ordinary sand filters the filtration diminishes daily as the surfaces become choked, especially when with slimy deposits. The washing of the filter beds can be performed on the same system as that now employed by the water companies.

As these calculations are based upon the results obtained with a pressure of liquid equal to one atmosphere only, it is evident that if a greater pressure were employed, within reasonable limits, an increased speed of filtration would be obtained, and that without detriment to the purity of the filtration; as was proved by the experiments at Coulommiers, where a pressure of two atmospheres was used.

Manufactures.—It will readily be seen that, in addition to water and sewage, this automatic self-cleansing process may be expected to effect a revolution in all kinds of filtration, and will prove of great benefit to sugar makers, distillers, brewers, vinegar makers, and others who require pure, rapid, continuous, and economic filtration. It entirely supersedes and dispenses with the use of cloths or bags, which entail a considerable annual outlay, and which do not produce an average pure filtration. For brewers and distillers it would be specially useful in filtering the refuse, which at present contains a very large amount of good liquid, that is practically wasted, owing to the inability of any existing system to filter it continuously.

Advantages of Sawdust as a Filtering Material.—Taking bulk for bulk, it has been found that the following great advantages are in favor of sawdust, as against sand, etc.:

1. It is a cheaper commodity.

2. Its cost of conveyance is not a serious item, as it is with sand.

3. Much less manual labor is required in washing sawdust, chiefly on account of its lightness and portability.

4. It produces far purer filtration, because the grains of sawdust, when saturated, pack closely together, and the greater the pressure employed the tighter the grains become knit together, which cannot take place with sand.

5. More than three times the volume of liquid is filtered in a given time through sawdust than through the same bulk of fine sand, by this process. The reason is that the solid impurities are arrested immediately on the top surface of the sawdust, and are, therefore, instantly removed by the cutter, so that rapid and continuous filtration ensues; whereas with sand the impurities always penetrate some distance below the top surface, owing to the impossibility of making the grains of sand pack close enough together, even under great pressure. In fact the grains of sawdust tightly overlap each other under pressure, being thus equivalent to a number of pressed layers of fine cloths or blotting paper, and the sawdust bed is thus impervious to anything but pure liquid.

The question naturally arises, whether sawdust imparts any flavor to the filtered liquid, which, with sugar, etc., might be a disadvantage. The answer is that, after the liquid with which the sawdust has been saturated, previous to filtration, has been expelled, no flavor from the sawdust can be detected in the filtered liquid. The reason is that the liquid with which the sawdust was saturated is thoroughly absorbed into the loose grains of the sawdust like a sponge, and that the whole of this liquid is, under pressure, squeezed out of the grains, carrying with it the greater part of the flavor in the sawdust. The sawdust being then in a compressed state, the filtered liquid is prevented from entering into the interior of the grains, and in its rapid passage between the grains it does not carry with it any flavor therefrom.

In all cases the sawdust must be saturated with some clear liquid, prior to making the filter bed, in order to create capillary attraction equally in all directions, so that the filtered liquid shall flow equally through the whole of the bed.

Repeated tests have been made to ascertain if the liquid to be filtered drives before it the whole of the liquid used in the saturation of the bed prior to filtration. This has always been proved to be the case, by the following test: The amount of water used in saturating the bed has been carefully measured. So soon as this quantity had been extracted, and not till then, did the filtered sewage, or sugar juice, etc., pass out of the machine.

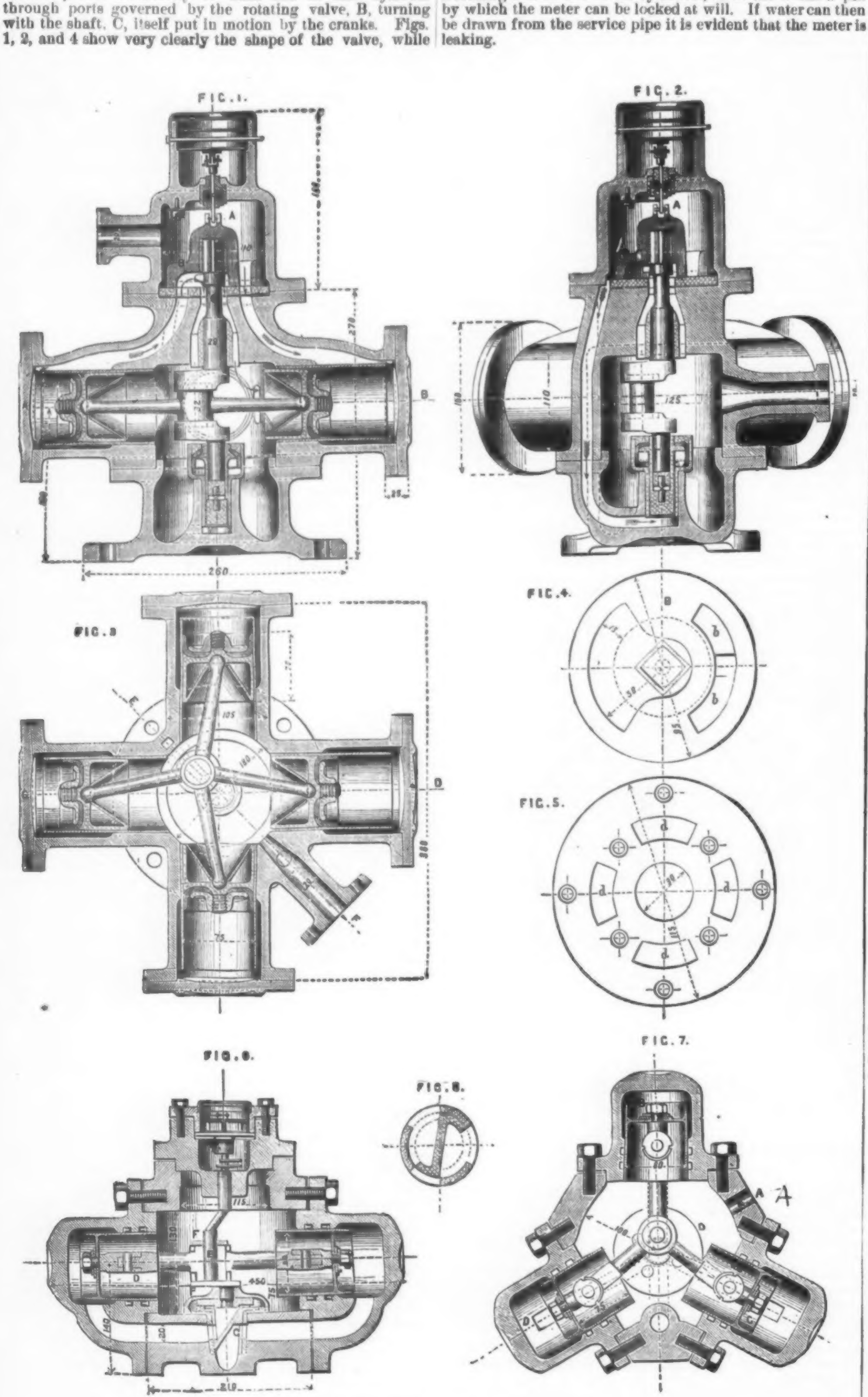
In conclusion, the author wishes to express his thanks to Mr. John Frederick Cook Farquhar, and Mr. Walter Oldham, the inventors of the process, for the assistance given in preparing this paper.

SURGERY BY THE ELECTRIC LIGHT.—Dr. Berkeley Hill, of London, recently operated for fistula, in University College, while the passage was lighted up by Coxeter's application of the glowing platinum wire. The apparatus consisted of a fine wire twisted into a knot, and through this knot was sent a continuous galvanic current strong enough to maintain the wire at a white heat. The wire was inclosed in a glass chamber, which was itself also inclosed in another glass cover. Through the space between the glasses a current of water was allowed to flow, in order to preserve a low temperature around the light, and a strong light was maintained for over an hour close to the margins of the fissure.

PARIS WATER METERS.

In consequence of the new regulations for the supply of Paris with water, which came into force on the 1st of January, the authorities have adopted four types of water meters. These are: first, Kennedy's; second, Frager's, manufactured by M. Michel, of Paris; third, that of M. Samain, an engineer of Blois; and fourth, the meter of MM. Mathelen and Deplechin, manufactured by MM. Mathelen and Garnier in Paris.

All the meters are of the piston type. We illustrate the two last named on page 124. Samain's meter has four cylinders; the water under pressure arrives through a pipe at the upper part, enters the distributing chamber, A, and from thence passes alternately to each end of each cylinder through ports governed by the rotating valve, B, turning with the shaft, C, itself put in motion by the cranks. Figs. 1, 2, and 4 show very clearly the shape of the valve, while sure on the back of each in turn. The piston, B, being at the end of its stroke, the two pistons, D and C, are put in motion by the pressure on their upper faces, and they drive the crank, F, to which they are coupled by the rods, F F. This crank in its turn puts the piston, B, in motion, and the water which filled the space behind the pistons escapes by the orifice, G, of the rotating valve, and at the same time a fresh quantity of water is admitted behind B. The crank drives the cock valve, as shown in Figs. 6, 7, and 8. It is divided into two compartments, one for admission and the other for exhaust. It works in a gun-metal casing having three openings or ports, the use of which requires no explanation. The axis puts the counter in motion. In order to facilitate the inspection of the meters they are provided with a stuffing box on one of the cylinders, in which works a pin by which the meter can be locked at will. If water can then be drawn from the service pipe it is evident that the meter is leaking.



THE PARIS WATER METERS.

Fig. 5 illustrates the shape of the port face surface. When one of the openings, *b*, of the valve comes over one of the ports in the seat, the water acts on the piston, and causing the rotation of the shaft end of the valve, which now closes the admission port, *d*, the piston then making a back stroke, pushed by the piston diametrically opposite, expels one cylinder full of water, as indicated by the arrows in Fig. 1. The water enters the central chamber of the meter, and escapes by the delivery pipe, as shown in Figs. 1 and 2. The action of all four cylinders is the same. The valve acts directly on the counter. The cylinders and pistons are of gun metal, the packings of leather. The average speed of the meter is sixty revolutions per minute.

Deplechin and Mathelen's meters are shown by Figs. 6, 7, and 8. It consists of three pistons and a rotating distributing valve. The water under pressure is admitted by the orifice, A, and presses equally on the faces of the three pistons, B, C, D, and motion is obtained by reducing the pres-

The merit of various water meters is just now an especially interesting question for the people of London, as the adoption of constant supply measured by meter and paid for accordingly is stoutly advocated by many persons, and has much to recommend it. It is by no means impossible that much will be said on the subject when Parliament finds time to legislate on the water supply of the metropolis. We are indebted to our esteemed contemporary, *Annales Industrielles* for the drawings of which our engravings are copies.

According to the present returns of the census held throughout the German Empire, the population of Berlin, including the military element, now numbers 1,118,630, or an increase of 154,390, or 16 per cent. on the figures of 1875, which were only 964,240. Since 1860, therefore, when the census gave 528,900, Berlin has more than doubled the number of its inhabitants.

RAVEL'S GAS MOTOR.

Gas motors are daily coming into greater favor with the smaller manufacturers, who see advantages in them which we have often pointed out, but to which it is not necessary to refer to again on the present occasion. All those which have been hitherto constructed are based on the expansion

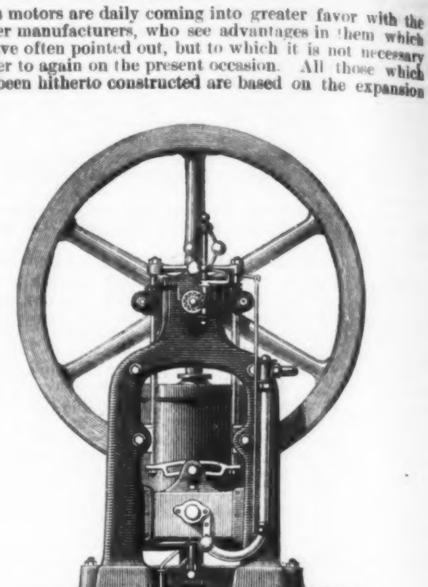


Fig. 1.—RAVEL'S GAS MOTOR. Elevation.

produced by the quick heating of an explosive mixture introduced into a cylinder. In a motor of this nature, then, all is dependent on the introduction into the cylinder and the firing therein of the detonating mixture, under as practical conditions of economy and simplicity as possible. The Ravel motor—an elevation, profile, and transverse section of

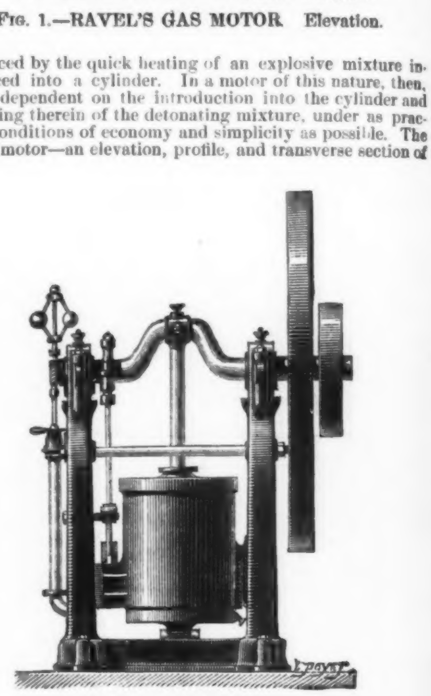


Fig. 2.—PROFILE.

which we reproduce herewith from *La Nature*—is said to fulfill these conditions very well. It is a simple action oscillating engine, that is, the motive action takes place once per revolution, during the ascent of the piston. The admission of the air and gas is effected at the left (Fig. 3), and the discharge at the right side. The distributing valve, which

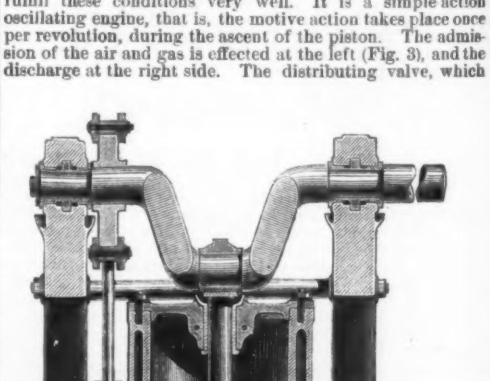


Fig. 3.—LONGITUDINAL SECTION.

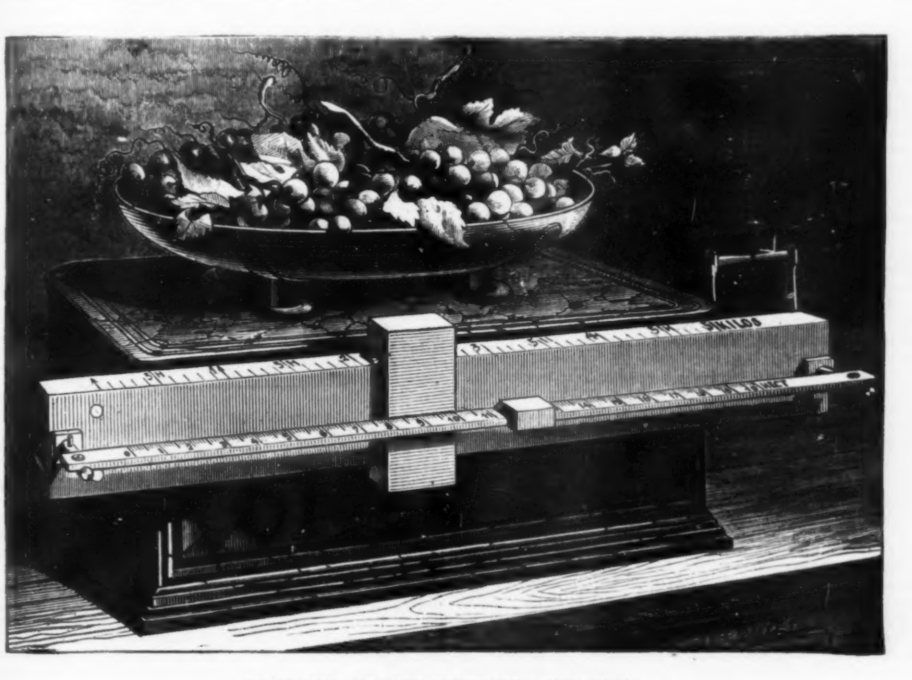
is maneuvered by an eccentric fixed on the driving shaft, introduces the mixture during about one-third of the travel. At this moment the mixture is lighted by a gas jet which is kept burning continuously on the outside, under conditions analogous to those found in the Otto motor, thus dispensing with the use of piles and of the Ruhmkorff coil, as in the

first apparatus of Lenoir. The discharge is effected through a sliding valve, as in ordinary oscillating engines, and the hollow frame itself serves as a discharge pipe. This arrangement of a vertical oscillating cylinder has two advantages: first, that of reducing the space occupied by the engine, which therefore becomes less cumbersome; and second, that of simplifying the distributing and transmitting mechanism.

With a fly-wheel of equal dimensions and weight of one in an Otto engine, this motor has a greater regularity of motion than the latter. What contributes still further to this regularity is the fact that the speed regulator acts so as to modify the entrance of the gas and consequently the composition of the mixture, but never completely suppresses the stroke of the piston. Under such circumstances, the Ravel motor, very greatly simplified in its construction, is of a nature to find many applications in cases where this regularity is necessary, and more especially in electric lighting. The cooling of the cylinder in this engine is effected through water circulating in the jacket which surrounds it. Rubber tubes connect the entrance and exit of the water in the latter with corresponding tubes fixed to the frame. It consumes about nine gallons of water per horse and per hour. The methods of starting and stopping are extremely simple, and the motor is easily kept in order and can work for a long time without surveillance. All these qualities, in addition to those that are possessed by gas motors in general, will undoubtedly be of a nature to extend its use among the smaller industries.

SCALES WITHOUT WEIGHTS.

WE represent herewith, from *La Nature*, a new system of scales in which sets of separate and detached weights are dispensed with, along with the various annoyances connected with their use. In these new scales, which are the invention of M. Coulon, of Paris, the weighing is effected instantaneously by means of metal slides moving on graduated beams, which form a part of the apparatus. The mechanism is very simple; it is a combination of the Berenger and Roman systems, and consists solely of articulated levers. When an object is to be weighed it is placed in the scale-pan, and under the action of its weight the double beam arises at the end opposite the zeros. Then the large slide is moved along its beam until the latter comes to a horizontal position, and the operator examines the divisions to see at what point the slide stands. If it is found located between any two divisions it is moved back to the smaller of the two, and equilibrium is established by moving the smaller slide along the lower beam. The larger slide gives kilogrammes (when the scale is intended for use where the metric system is employed), and the smaller one gives hectogrammes and intermediate fractions down to a gramme. These scales have another valuable feature connected with them, that of allowing the price of the article weighed to be verified at a glance. This result is obtained by means of a graduated rule entirely independent of the scales, and the graduation of which corresponds with the price of the merchandise. This supplementary rule is not shown in the engraving, but it suffices to say that when used it is placed between the two graduated beams. These rules may be made in sets adapted for use in weighing various sorts of goods, such as sugar, meat, fruit, etc., etc.



COULON'S SCALES WITHOUT WEIGHTS.

GAS AND ELECTRICITY AS HEATING AGENTS.

By DR. C. W. SIEMENS, F.R.S., etc.*

ON the 14th of March, 1878, I had the honor of addressing you "On the Utilization of Heat and other Natural Forces." I then showed that the different forms of energy which nature has provided for our uses had their origin, with the single exception of the tidal wave, in solar radiation; that the forces of wind and water, of heat and electricity, were attributable to this source; and that coal formed only a seeming and not a real exception to the rule—being the embodiment of a fractional portion of the solar energy of former geological ages.

On the present occasion I wish to confine myself to one branch only of the general subject—namely, the production of heat-energy. I shall endeavor to prove that for all ordinary purposes of heating and melting, gaseous fuel should be resorted to; but that for the attainment of extreme degrees of heat, the electric arc possesses advantages unrivaled by any other known source of heat.

Carbonaceous material, such as coal or wood, is practically inert to oxygen at ordinary temperatures; but if wood is heated to 295° C. (593° Fahr.), or coal to 326° C. (617° Fahr.), according to experiments by M. Marbach, combination takes place between the fuel and the oxygen of the atmosphere, giving rise to the phenomenon of combustion. It is not necessary to raise the whole of the combustible materials to this temperature in order to continue the action. The very act of combustion, when once commenced, gives rise to a great development of heat—more than sufficient to prepare additional carbonaceous matter and additional air for entering into combination. Thus a match suffices to ignite a shaving, and this in its turn to set fire to a building.

The first effect of combustion is, therefore, to heat the combustible and the air necessary to sustain combustion to the temperature of ignition; but in dealing with the combustible called coal, other preparatory work has to be accomplished besides mere heating, in order to sustain combustion. The following is an analysis, from Dr. Percy's work on "Fuel," of a coal from the Newcastle district:

Carbon	81·41
Hydrogen	5·83
Oxygen	7·90
Nitrogen	2·05
Sulphur	0·74
Ash	2·07

This shows at a glance that nearly 16 per cent. of the total weight consists of such permanent gases as hydrogen, oxygen, and nitrogen. These gases are partly occluded or absorbed within the coal, but are also combined with carbon, forming volatile compounds, such as the hydrocarbons and ammonia; so that when coal is subjected to heat in a closed retort, as much as 34 per cent. passes away from the retort in a gaseous condition and as vapor of water, partly to condense again in the form of tar and ammoniacal liquor, and partly to pass into the gas-mains as illuminating gas—a mixture mainly of marsh gas (CH_4), olefiant gas (C_2H_4), and acetylene (C_2H_2); its value as an illuminant depending upon the percentage of the last two constituents, rich in carbon. The result of the distillation of a ton of coal will be as follows, from data with which Mr. Alfred Upward has kindly supplied me:

	Cwt.
Coke	13·60
Tar	1·20
Ammoniacal liquor	1·45
Gas	3·15
Carbonic acid	0·18
Sulphur—removed by purifying	0·30
Loss	0·12

So great is the loss of heat sustained in an ordinary coal fire, in consequence of the internal work of volatilization, that such a fire is scarcely applicable for the production of intense degrees of heat, and it has been found necessary to deprive the coal in the first place of its volatile constituents (to convert it into coke), in order to make it suitable for the blast furnace, for steel melting, and for many other purposes where a clear intense heat is required.

In the ordinary coke oven the whole of the volatile constituents are lost, and each 100 lb. of coal yield only 66 lb. of coke, including the whole of the earthy constituents, which on a large average may be taken at 6 lb., leaving a balance of 60 lb. of solid carbon. In burning these 60 lb. of pure carbon 220 lb. of carbonic anhydride (CO_2) are produced, and in this combination $60 \times 14,500 = 870,000$ heat units (according to accurate determinations by Favre and Silbermann, Dulong and Andrews) are produced.

The 34 per cent. of volatile matter driven off yield—when the condensable vapor of water, ammonia, and tar are separated—about 16 lb. of pure combustible gas (being equal to about 10,000 cubic feet per ton of coal), which in combustion produce $16 \times 22,000 = 352,000$ heat units. The escape of these gases from the coke-oven constitute a very serious loss, which may be saved, to a great extent at least, if the decarburization is effected in retorts. The total heat producible from each 100 lb of coal is in that case $870,000 + 352,000 = 1,222,000$ or 12,220 units per pound of coal. Deduction from this must, however, be made for the heat required to volatilize 34 lb. of volatile matter for every 100 lb. of coal used, and also for heating the coke to redness, or, say, to 1,000° Fahr. Considering the multiplicity of gases and vapors produced, it would be tedious to give the details of this calculation, the result of which would approximate to 60,000 heat units, or 600 units per pound of coal treated.

We thus arrive at $12,200 - 600 = 11,600$ heat units as the maximum result to be obtained from one pound of best coal. Considering, however, that the coal commonly used for industrial purposes contains more ashes and more water than have been here assumed, a reduction of, say, 10 per cent. is necessary, and the calorific power of ordinary coal may fairly be taken at 10,500 units per pound.

In applying this standard of efficiency to actual practice, it will be found that the margin for improvement is large indeed. Thus, in our best steam-engine practice we obtain one actual horse power with an expenditure of two pounds of coal per hour (the best results on record being 1·5 lb. of coal per indicated horse power). A horse power represents $33,000 \times 60 = 1,980,000$ foot-pounds per hour, which is $1,980,000 \div 2 = 990,000$ foot-pounds, or units of force, per pound of fuel. Dr. Joule has shown us that 772 foot-pounds represent one unit of heat, and one pound of coal therefore produces $990,000 \div 772 = 1,282$ units of heat, instead of 10,500, or only one-eighth part of the utmost possible result.

In melting steel in pots in the old fashioned way, as still practiced largely at Sheffield, 2½ tons of best Durham coke are consumed per ton of cast steel produced. The latent and sensible heat really absorbed in a pound of steel in the operation does not exceed 1,800 units, whereas 2½ lb. of coke are capable of producing $13,050 \times 2·5 = 32,625$ units, or 18 times the amount actually utilized.

In domestic economy the waste of fuel is also exceedingly great; but it is not easy to give precise figures representing the loss of effect, owing to the manifold purposes to be accomplished, including cooking and the heating and ventilation of apartments. If ventilation could be neglected, close stoves, such as are used in Russia, would unquestionably furnish the most economical mode of heating our apartments; but health and comfort are, after all, of greater importance than economy, and these are best secured by means of an open chimney. Not only does the open chimney give rise to an active circulation of air through the room, which is a necessity for our well-being, but heat is supplied to the room by radiation from the incandescent material, instead of by conduction from stove surfaces. In the one case the walls and furniture of the room absorb the luminous heat-rays, and yield them back to the transparent air; whereas in the latter case the air is the first recipient of the stove heat, and the walls of the room remain comparatively cold and damp, giving rise to an unpleasant musty atmosphere, and to dry rot or other mouldy growth. The adversaries of the open fire-place say that it warms you on one side only, but this one-sided radiant heat produces upon the denizens of this somewhat humid country, and indeed upon all unprejudiced people, a particularly agreeable sensation. This is proof, I think, of its healthful influence. The hot radiant fire imitates, indeed, the sun in its effect on man and matter, and before discarding it on the score of wastefulness and smokiness, we should try hard, I think, to cure it of its admitted imperfections.

If incandescent coke is the main source of radiant heat, why, it may be asked, do we not at once resort to coke for our domestic fuel? The reasons are twofold—the coke would be most difficult to light, and when lighted would look cheerless without the lively flickering flame.

The true solution consists, I venture to submit, in the combination of solid and gaseous fuel when brought thoroughly under control, by first separating these two constituents of coal. I am bold enough to go so far as to say that raw coal should not be used as fuel for any purpose whatsoever, and that the first step toward the judicious and economic production of heat is the gas-retort or gas-producer, in which coal is converted either entirely into gas or into gas and coke, as is the case at our ordinary gas-works.

When, in the early part of the present winter, London was visited by one of its densest fogs, many minds were directed toward finding a remedy for such a state of things. In my own case it has resulted in an arrangement which has met with a considerable amount of favor and practical success, and I do not at all hesitate to recommend it to you also for adoption. One arrangement of this grate is here represented.* The iron dead-plate, *c*, is riveted to a stout copper plate, *a*, facing the back of the fire-grate, and extending five inches both upward and downward from the point of junction. The dead-plate, *c*, stops short about an inch behind the bottom bar of the grate, to make room for a half-inch gas-pipe, *f*, which is perforated with holes of about $\frac{1}{16}$th of an inch, placed at distances of 1½ inches along the inner side of its upper surface. This pipe rests upon a lower plate, *d*, which is bent downward toward the back, so as to provide a vertical and horizontal channel of about one inch in breadth between the two plates. A trap-door, *e*, held up by a spring, is provided for the discharge of ashes falling into this channel. The vertical portion of the channel is occupied by a strip of sheet copper about four inches deep, bent in and out like a lady's frill, and riveted to the copper back piece. Copper being an excellent conductor of heat, and this piece presenting (if not less than ¼ inch thick) a considerable sectional conductive area, transfers the heat from the back of the grate to the frill-work in the vertical channel. An air-current is set up by this heat, which in passing along the horizontal channel impinges on the line of gas flames and greatly increases their brilliancy. So great is the heat imparted to the air by this simple arrangement that a piece of lead of about half a pound in weight introduced through the trap-door into the channel melted in five minutes, proving a temperature exceeding 619° Fahr.; or 326° C. The abstraction of heat from the back has, moreover, the advantage of retarding the combustion of the coke there while promoting it at the front of the grate.

This fire-place was set up at my office, which is a room of 7,200 cubic feet capacity, facing the north. I always found it difficult during cold weather to keep this room at 60° Fahr. with a coal fire, but it has been easily maintained at this temperature since the grate has been altered to the gas-coke grate just described.

In order to test the question of economy I have passed the gas consumed in the grate through a Parkinson's ten-light dry gas-meter, supplied to me by the Woolwich, Plumstead, and Charlton Consumers' Gas Company. The coke used was also carefully weighed. The result of a day's campaign of nine hours was a consumption of 62 cubic feet of gas and 22 lb. of coke—the coke remaining in the grate being in each case put to the debit of the following day. Taking the gas at the average London price of 3*s*. 6*d*. per 1,000 cubic feet, and the coke at 18*s*. per ton, the account stands thus for nine hours:

62 cubic feet of gas at 3*s*. 6*d*. per 1,000 feet	2·604*d*.
22 lb. coke at 18*s*. per ton	2·121
Total	4·725*d*.

or at the rate of 0·525*d*. per hour. In its former condition, as a coal-grate, the consumption generally exceeded 2½

*A lecture delivered Thursday, Jan. 27, at Glasgow, under the auspices of the Science Lectures Association.

* A diagram was shown similar to that reproduced in the *Journal* of Nov. 23 last year, vol. xxxvi., p. 807.

large scuttles a day, weighing 19 lb. each, or 47 lb. of coal, which at 23s. a ton equals 5·7d. for nine hours, being 0·633d. per hour. This result shows that the coke-gas fire, as here described, is not only a warmer but a cheaper fire than its predecessor, with the advantages in its favor that it is lit without the trouble of laying the fire, as it is called, and keeps alight without requiring to be stirred, that it is thoroughly smokeless, and that the gas can be put off or on at any moment, which in most cases means considerable economy.

A second and more economical arrangement, as regards first cost, consists of two parts, which are simply added to the existing grate, viz.: (1) a gas-pipe with a single row of holes about $\frac{1}{16}$th inch diameter, 1·5 inches apart along the upper side, inclining inward, and (2) an angular plate of cast-iron, with projecting ribs extending from front to back on its under side, presenting a considerable surface, and serving the purpose of providing the heating surface produced by the copper plate and frill-work in my first arrangement. In using iron instead of copper, it is necessary, however, to increase the thickness of the plates and ribs in the inverse ratio of the conductivity of the two metals, or, as regards the back plate, from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch. An inclined plate fastened to the lower grate-bar directs the incoming air upon the heating surfaces, and provides at the same time a support for the angular and ribbed plate, which is simply dropped into its firm position between it and the back of the grate. The front edge of the horizontal plate has vandyked openings, forming a narrow grating through which the small quantity of ashes that will be produced by combustion of coke or anthracite in the front part of the grate discharge themselves down the incline toward the back of the hearth, where an open ash-pan may be placed for their reception.

In adapting the arrangement to existing grates, the ordinary grating may be retained to support the angular plate, which has in this case its lower ribs cut short to the level of the horizontal grade.

A considerable number of grates have now been constructed or altered in accordance with my plan, and have given great satisfaction to the users, on account of convenience and economy, which are conditions essentially necessary, if we are to make any way toward the more important, I may say national, result of a smokeless London, a smokeless Manchester, and a smokeless Glasgow.

But it may be asked, Are you sure that the coke and gas grate you advocate will do away with fogs and smoke? My answer is, that it would certainly do away with smoke, because the products of combustion passing away into the chimney are perfectly transparent. Mr. Aitken has, however, lately proved, in an interesting paper read before the Royal Society of Edinburgh, that even with perfect combustion a microscopic dust is sent up into the atmosphere, each particle of which may form a molecule of fog. We have evidence, indeed, that the whole universe is filled with dust, and this is, according to Professor Tyndall, a fortunate circumstance, for without dust we should not have a blue but a pitch-black sky, and on our earth we should be, according to Mr. Aitken, without rain, and should have to live in a perpetual vapor bath. The gas fires would contribute, it appears, to this invisible dust, and we should, no doubt, continue to have fogs, but these would be white fogs, which would not choke and blacken us.

Granted the cure of smoke, it might still be questioned whether such a plan as is here proposed could be carried out on so large a scale as to affect our atmosphere, with the existing mains and other plant of the gas-works. If gas were to be depended upon entirely for the production of the necessary heat, as is the case with an ordinary gas and asbestos grate, it could easily be proved that the existing gas mains would not go far to supply the demand. Each grate would consume from 50 to 100 cubic feet an hour, representing in each house a consumption exceeding many times the supply to the gas lights. My experiments prove, however, that an average consumption of from 6 to 8 cubic feet of gas per hour suffices to work a coke-gas grate on the plan here proposed. This is about the consumption of a large Argand burner, and therefore within the limits of ordinary supply.

But independently of the practical question of supply, it is desirable, on the score of economy, to rely upon the solid carbon chiefly for the production of radiant heat, for the following reason: One thousand cubic feet of ordinary illuminating gas weigh 34 lb., and the heat developed in their combustion amounts to $34 \times 22{,}0\ 0 = 748{,}000$ heat units. One lb. of solid coke develops in combustion say 13,400 heat units (assuming 8 per cent. of incombustible admixture); and it requires $748{,}000 \div 13{,}400 = 56$ lb., or just half a hundredweight, of this coke to produce the same heating effect as 1,000 cubic feet of gas. But 1,000 cubic feet of gas cost, on an average, 3s. 6d., and half a hundredweight of coke not more than 6d. (at 20s. a ton) or only one-seventh part of the price of gas.

If heating gas could be supplied at a much cheaper rate, it would in many cases be advantageous to substitute incombustible matter, such as balls of asbestos, for the coke or anthracite. The consumption of gas would in this case have to be increased very considerably, but the economical principle involved (that of heating the air of combustion by conduction from the back of the grate) would still apply, and produce economical results as compared with those obtained by the gas asbestos arrangements hitherto used.

(To be continued.)

A CHEAP AND EFFECTIVE FINISHED ENLARGEMENT.

By G. CROUGHTON.

A FINISHED enlargement, which shall be cheap and *not* nasty, is greatly to be desired.

My object in writing this paper is to give plain and practical instruction for the production of cheap and effective enlargements which shall successfully rival the productions sent out by those firms who have pushed the club mania to an excess, and I write from practical experience, having had much to do with this class of picture.

First for the enlargements. My enlarging apparatus is in the dark room; it has more than once been described in the pages of the *News*, so that I will not take up space here by describing it again. Get one dozen 12 by 10 flatted crown glasses. I use Houghton's O marked, for then I am always sure of the right side, and keep them always for this one purpose. They must first be soaked in strong soda solution for one night, then passed into an acid solution (either sulphuric or hydrochloric acid will do, three ounces of acid to two quarts of water); wash well under the tap from the acid, and dry with a clean cloth, and polish with wash leather. Now, on the unmarked side, pour a small pool of the waxing solution, made by dissolving one drachm of yellow beeswax in three ounces of benzole. Spread it evenly with a clean linen rag, and polish with another with a light, brisk rub, till all smears are gone. The plate is now ready for coating; any good collodion which has been iodized some time will do. I use the Autotype Company's, and find it answer the purpose capitally. Rock the plate well to prevent streaks, and let the collodion set well before putting the plate into the bath. Do not use either a new or a strong bath; one which has been discarded as too old and weak for negative work is best. It must be acid with nitric acid, three drops of strong acid to a quart of bath solution. Do not hurry the plate into the bath. When well coated, drain well before putting it into the enlarging camera. The exposure will, of course, vary, with the light and the intensity of the negative, from five to fifteen minutes. I develop with iron. The formula stands thus:

Protosulphate of iron	6 drachms.
Glacial acetic acid	2 ounces.
Citric acid	60 to 80 grains.
Sugar-candy	30 "
Distilled water	20 ounces.

With this developer you will not want to tone the transparency; it should develop very slowly, the deepest shadows in the drapery showing first, and as soon as the detail appears in the half-tones on the face, wash off quickly, and immerse in hyposulphite, four ounces to the pint of water. When fixed it must be well washed.

Before going on with the details of transferring we will retrace our steps for further details. First the waxing. There may be some difficulty, when first using new plates, in stripping the transfer from the glass; it is necessary, therefore, with new plates, to wax and polish with particular care. See that every part of the glass is well smeared with the wax before proceeding to polish, and do not rub too hard in polishing; when the first transfer has come off you will find no difficulty in stripping afterward. Next with regard to development. A great deal depends upon judgment used as to both exposure and development. Remember that a hard negative may be made to produce a soft transfer by a prolonged exposure with short development, and a brilliant transfer may be obtained from a weak thin negative by shorter exposure and prolonged development, and sometimes with this class of negative a great improvement can be effected by adding one ounce of water to two ounces of developer.

For transferring, I use the Autotype Company's double transfer paper. This is sold in bands. Cut it to the size of your glasses, and soak for twenty minutes in *clean* cold water; when your plate has been well washed from the fixing, transfer your paper from the cold water to hot, till the surface feels slimy, and place face down upon your still wet collodion surface, and squeegee down lightly but firmly from the center outward. When dry, they should leave the glass of themselves, but if they should stick at the edges, run a knife round, and they will come away. Mount with strong starch or thin glue upon stout board, and, when dry, roll well.

A collodion transfer made in this way is, or should be, both soft and of good color, only wanting in depth in the deepest shadows, a fine engraving black, with a highly glazed surface.

And now comes the most important part, the working up or finishing. This I do with both chalk and pencil, and, if judiciously done, I find they are preferred to the loud oil daubings which is the characteristic of many club portraits; and they can be done very quickly. Any girl who is used to spotting prints could very soon get into the method of working these pictures, provided she had a little taste, and they are capable of the highest finish in artistic hands, with much less work than any other kind of enlargements.

First, for the materials required. (1) Pumice powder. This should be screened through a double thickness of fine muslin; a small quantity is sprinkled over the print, and rubbed lightly and evenly all over, till the surface of the print is matt in every part. (2) Conti crayon in cedar—red and black; that is, the outside of the wood is red with the harder kind and black with the softer. I have found these are the best kind of crayon; they are of French make, and can be obtained at Rowney's, Rathbone place; three black-lead pencils I use, the same maker's ever-pointed H, H B, and B.

Pin your print upon a firm drawing-board, and commence, with the softest crayon, to deepen the shadow of the drapery, following the photographic shadow. Don't mind if the crayon marks too much, for it can be easily softened, using the finger for a stump; when you have depth enough, go over it again with the point of the harder crayon, filling up and going over parts which may be broken. If the hair is dark brown or black, it may, perhaps, need the same treatment with the crayon. Be careful to keep to the photographic shadows; your work is to strengthen and define existing shadows, not to put new ones in. If the operator can hatch, a few bold strokes of cross-hatching upon the background, over the shoulders, will give great effect. Now take your pencils: with the B pencil, the point of which should not be too sharp—a round blunt point—go over the deepest shadows of the face, strengthen and define the eyebrows, carefully noting and keeping the darkest parts of them in their right place, next the shadows under them, softening the pencil with the finger, in the same manner as the crayon. Next attend to the line of the eyelash, and the less-defined line of the upper eyelid above it; do not define this too sharply. Now carefully attend to the eyes, strengthening and defining the pupil and the dark line round the ball, carefully preserving the high and reflected lights. Generally speaking, the high light upon the eye will be too large and too bright; work on each side of it with the B pencil and lower it with the H. Now the shadow down the nose and under it will want attending to, and the nostrils want deepening; then the upper lip and the line between the lips; then the chin and the shadow under it; and if the ear is seen, the deeper shadow of that must be touched upon.

Now, with the H B pencil, mend the shadows of the face, working from the deepest shades toward the lights, using the H pencil as you near the highest lights upon the face. This part of the work is the most important, and it can stop at simple mending, or can be carried on till the face is stippled all over with the pencil. If any part or touch of the pencil should be worked too dark, it can be brightened with a piece of bread, or removed altogether with ink eraser. If all this has been done, the picture now only wants the highest lights more sharply defined to finish it. This is done by scraping an eraser—such as is used by water-color artists is the instrument used—and this can be obtained of any artist's colorman; it must be kept as sharp as a razor. With this scraper it is possible to get great effect in the lights, the lights on the face can be brightened, the light in the eye, on the white collar, etc., can be brought out with a brilliancy which is surprising to those who do not know how it is done. It is best to finish throughout with chalk and pencil, but should some deeper touches be desired than can be obtained by the softer crayon, they can be put in with water color, carefully mixed, to match the color of the print, but used *without gum water*.

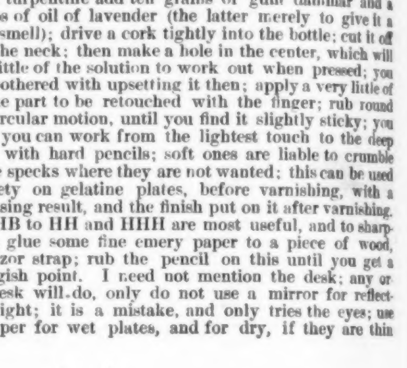
One word about mounting. Do not have a white mount round these pictures; a neutral gray or greenish gray mount, not too deep, is the best for them; and although instructions may read a little complicated, it will be found upon trial much easier to do than one would think from reading this description.—*Photo. News.*

RETOUCHING FOR BEGINNERS.

By HENRY MORGAN.

FOR the benefit of the beginner I think it necessary to commence the subject with the description of negative most suitable to work upon, the pencils to use, etc., so that he shall not get disheartened with his first few strokes caused by an unsuitable bite. I will give him the preliminary requirements, and, having started him, he will be in a fair way to learn, with patience, the beautiful art, for such it is when worked wisely, but not too well.

The negative most suitable for retouching is one which is well exposed (not flat), but with full detail; such a negative is usually got with the first development, if the negative bath, collodion, etc., work in unison; if it be much under or over exposed, it must be left to the more experienced, but such a negative as the above is the one for the beginner to start with. The varnish should be hard (more especially for gelatine plates). The best medium I find is this: To one ounce of spirits of turpentine add ten grains of gum dammar and a few drops of oil of lavender (the latter merely to give it a pleasant smell); drive a cork tightly into the bottle; cut it off close to the neck; then make a hole in the center, which will allow a little of the solution to work out when pressed; you are not bothered with upsetting it then; apply a very little of this to the part to be retouched with the finger; rub round with a circular motion, until you find it slightly sticky; you will find you can work from the lightest touch to the deep shadows with hard pencils; soft ones are liable to crumble and leave specks where they are not wanted; this can be used with safety on gelatine plates, before varnishing, with a very pleasing result, and the finish put on it after varnishing. Faber's HB to HH and HHH are most useful, and to sharpen them, glue some fine emery paper to a piece of wood, like a razor strap; rub the pencil on this until you get a fine, longish point. I need not mention the desk; any ordinary desk will do, only do not use a mirror for reflecting the light; it is a mistake, and only tries the eyes; use white paper for wet plates, and for dry, if they are thin



and rather yellow, use paper of a bluish or greenish tint, and less light—or, better still, retouch through very thin opal; this gives more body to gelatine negatives.

Before starting, please remember the three P's—patience, perseverance, and practice; bear in mind these, and success is certain. Do not be in a hurry to get over the face with dots and lines, piling on the lead with the idea of making a grand stipple; if you do, you will be sorely disappointed when you fancy it finished; but take it easy. Commence at the right hand side of the forehead, with light, circular strokes through the imperfections, from right to left, blending, as you go, the uneven parts with their surroundings; do not touch on any part but these; continue to the temples; turn the negative, and work the cheek, the deep shadows under the eye, and about the nose and mouth; do not obliterate, but soften them; continue working in the direction of the facial lines, always inclining them inward, which gives rotundity. If you follow these instructions, you will find the dirt, as it were, worked out of a face which is sufficient to produce a good print. A considerable amount of practice is required to give what is termed a stipple, and is produced by various systems of working. A very fine effect is produced by dots alone, another by dots with tails, and by crosses curved; but the beginner must not tread out of his path until he has mastered his first lesson, and can work on a face without leaving patchy traces of the pencil; then he can try his hand on any fancy work he likes, and can stick to any method he thinks proper; but the least work with the most effect is to be aimed at. In using color for stopping out holes, etc., that will not take sufficient lead, neutral tint for wet and olive green for dry negatives with yellow films. Do not be disappointed with your first attempt; I promise you plenty of troubles with the different kind of negatives, but plod on. With my first lessons I used to watch the retoucher attentively, and gaze on in wonder and admiration to see him with apparently careless curves blend and stipple most beautifully, which seemed to me a mystery then; but as I stuck hard at it, I found, when I had mastered the strokes, that I was able to work either very smooth or stipple; then it was safe to employ any system. If the work on a negative is not satisfactory, you can take it off with a handkerchief moistened with the least drop of the medium, and commence again.

I must warn the beginner not to pile on the work, but work as lightly as possible, and have patience—he will soon see the effect—not as I did. When I first commenced, I piled on the work—too much lead, and no effect. I was going to say the negative was heavy with the lead. However, I could not put any more on it, and, as I have, you will have to buy your experience.

For those who would like to practice at night, a certain kind of light is required; this can be produced easily, which will be seen in the sketch.

An ordinary tin lamp, with reflector, costs about two shillings, which is placed behind the desk. Use a piece of opal

(the dead side) for the lamp to reflect on; place a small box or anything handy under the aperture, so as to bring it within an inch of it; by varying the light you can suit it to thick or thin negatives. I do not find it injurious to the sight; but it would be advisable for any one to wear spectacles with a blue or green tint, for without good eyesight the photographer is lost.—*Photographic News.*

CHLORIDE OF SILVER GELATINE EMULSION.

By H. L. T. HAAKMAN.

IT seems that the production of glass transparencies by means of an emulsion of chloride of silver in gelatine is meeting with greater attention.

About two years ago I devised a process which adds simplicity to good results, and at the time I forwarded a few sample prints on glass to Mr. Wharton Simpson. Possibly those samples may still be found somewhere in the editorial snuggery of the *Photographic News.* As I never published my process, and I do not remember having seen anywhere a description of anything similar, the following may, perhaps, interest your readers.

I must warn them, however, that a method to produce and print by chloride of silver gelatine emulsion has been patented in England by somebody, whose name I forgot, and it may be that this patent is still valid. I never saw the specification thereof, and so it may be that my process is something quite different, and open to all, in which case, I say, you are heartily welcome to it. My formula stands as follows:

Gelatine	5	grammes.
Nitrate of silver	1½	gramme.
Chloride of calcium	½	"
Citric acid	½ to 1	"
Water	100	grammes.

Dissolve the gelatine (any good kitchen kind will do) in part of the water, and do the same with the chemicals in the remaining part, keeping, of course, each ingredient in a separate bottle. When the gelatine has melted (say) at about 100° to 115° Fahr., pour the silver into it first, well mixing; then the chloride calcium, stirring well, a little at a time; and, finally, the citric acid. The emulsion will probably turn red, but this does not matter. While still warm, filter through flannel, and coat your plates in the usual way. No washing is required; and, in fact, it would spoil the plates and deprive them of their sensibility.

The plates are laid on glass or marble to set, and afterward placed in the drying box to dry spontaneously. When dry, they are printed under negatives by contact in the same way as albumenized paper, only, as the prints are to be viewed as transparencies, and they lose much in fixing, they must be printed very deep.

When the emulsion is in good condition the shadows will bronze very readily, and the whole print gets proper intensity; but when the emulsion is bad, the print will scarcely come up to a dirty yellow, and then the shadows solarize. It is, therefore, a good plan, when the emulsion is made, and before coating the plates, to pour a few drops of the emulsion on a strip of glass and expose this to the light. A good emulsion will speedily turn intensely black; a bad one solarizes and turns yellow. In this case more citric acid has to be added. With this simple precaution success is certain.

The prints have to be toned. I never succeeded very well with the usual gold bath, and prefer to use either the old *sel d'or* bath (hyposulphite with gold), or sulphocyanide with gold. This bath allows of a very great variety of tones—from sepia to engraving black. The toned prints are washed thoroughly, fixed in a weak hyposulphite bath, washed, treated with alum, washed again, and left to dry spontaneously. The printing may be done on matt glass, or the prints, when dry, varnished with a matt varnish, of which the *News* has given several very good recipes.

This process has one or two advantages over chloride of silver in collodion. First, it is much cheaper; then, no fuming with ammonia is necessary; while last, but not least, there is no crystallization on or in the film.

With one print I obtained the curious phenomenon that, when taking it out of the printing frame, the foliage of the trees was green, a bridge yellow, and the water underneath greenish brown. I kept it as a curiosity, unfixed and untoned, and, after a year, the colors had remained. I have not opened the box plate since May last, and, for all I know, the colors may still be there.—*Photo. News.*

PELLICULAR NEGATIVES AND GELATINE PLATES.

To strip negatives from the glass support and keep them in a portfolio must always be the aim of those who, like myself, spend some part of the year away from home roving with the camera.

Wet-plate films and collodion emulsion are generally too glad to come off the glass of their own accord—sometimes when not required; but gelatine adheres far too firmly to permit of its being removed by the usual method of another film. Here is a simple way of doing it:

Dissolve gum dammar in chloroform in the proportion of twelve to eighteen per cent.; varnish the gelatine negative with this and dry, after which place the negative in water, which, for convenience, ought to be at least four or five inches in depth. After some little time, varying according to the thickness of the compound film, the latter will float off if the borders have been previously cut around with the point of a knife, and this by the law of frilling—that *bête noire* of beginners! The only trouble now is to take it up and dry it. This can be done by using a glass rod, after having attached a strip of cardboard to the lower and opposite edge so as to prevent its rolling up. But the best way is to rub a glass plate with oil, and then, introducing it under the floating film with the oiled surface uppermost, to raise the whole together. A little care is required to smooth out the film over the glass while still in the water, and this can be done with a soft camel's-hair brush. When dry strip it off, the oil preventing it from adhering.

Gelatine plates are now so thickly coated that the varnish suffices to produce a compound film quite strong enough to permit of its being handled while printing, and yet so thin that proofs can be drawn from either side—an immense advantage in economy of labor. Clean plates are required for the film to leave them easily; but if any portion adhere a gentle pressure with a soft brush will make the film leave the glass.

Another season with its practice in the gelatine process has taught us much concerning its vagaries; but how is it that many of us are content to go on in the same groove, leaving quality for rapidity and false appearances, as if the rapidity were of more importance than the obtaining of good gradation and half-tint? A thick, creamy film is certainly a beautiful thing to *look at*, but worth little in general work; for, as development cannot be witnessed, as the film is not transparent, there can be no certainty as to when the proper density is reached. This is most important, for if carried too far the *rationale* of alkaline development is that half-tones are lost by being developed up more or less to the high lights.

Why not follow the advice given us in this journal some time ago of coating our glasses *thinly* with emulsion, developing, till the detail is out, with weak pyro and ammonia—there being no danger, as we can watch the transparent film—and then, after fixing and washing, intensifying with acid silver and pyro or iron; the last trace of hyposulphite having been dissolved out completely, there will be no red stain? Intensification can be carried on in yellow light, which is a comfort not to be despised; and, lastly, the half-tints and gradation are not obliterated.—*Harry Rogers, in British Journal of Photography.*

THE HYPOTHESIS OF AVOGADRO.

THIS hypothesis is at the present time the most fundamental assumption in chemistry, and of great importance, not only on account of the very far-reaching conclusions based upon it, but also on account of the existence of many doubts and perplexities concerning the vapor densities at higher temperatures, the nature and the variability of valency, the composition and classification of compounds; the general result being an enormous increase of the difficulties of the study of the science. The greater number of chemists seem to have adopted it or acquiesce in it; but very distinguished men, such as Berthelot and H. Sainte Claire Deville, are decidedly opposed to it.

The facts disclosed by Gay Lussac relative to the combination of gases by volumes, and the general experience on this point, leave not the least doubt that there is a connection between the specific gravities and the combining weights of gases; but the evidence to be produced makes it utterly impossible that the connection is that assumed in Avogadro's hypothesis, and the latter is, beyond all doubt, a grave error. No new facts are needed to demonstrate this; it is necessary only to put the hypothesis, and the conclusions following from it, to the test, to discover the delusion.

The hypothesis, so implicitly relied upon that many chemists designate it as a law, is to the effect that an equal volume of any gaseous body, under the same circumstances, contains the same number of molecules. From this assumption important conclusions follow:

1. The number of molecules being equal, the weights of volume or the specific gravities will express the molecular weights.

"The molecules will," in Avogadro's own words,* "be equidistant from each other in different gases, and placed at distances, which, in relation to the dimensions of the molecules, shall be exactly sufficient to neutralize their mutual attraction." According to the kinetic theory, this equidistance requires the repulsive energy of the molecules of all gases to be the same; and such equality of repulsive energy supposes the material of which molecules consist to be the same for the molecules of the different gaseous bodies, in so far that the molecules of all substances, though for each substance of different weight, have the same specific gravity. This molecular specific gravity, or that of the individual molecules, is not to be confounded with the specific gravity, which is the weight of the unit of volume.

If the repulsive energy were increased when they combine, the distances, by which the compound molecules in the gaseous state are separated, would also be increased, and the number of molecules in unit of volume would be reduced. The hypothesis involves, therefore—

2. One specific gravity for the different kinds of molecules, and its invariability in all processes of chemical action.

It is certain that hydrogen, chlorine, and the vapors of bromine and iodine contain the same number of molecules in unit of volume, and that, therefore, the molecules of these substances are equidistant, that the molecular specific gravity is the same; the proof being that they combine only in the one proportion of 1 vol. of hydrogen with 1 vol. of either of the remaining substances. The combination takes place without condensation, and the product is 2 vols. If the number of molecules in unit of volume is x, the theory requires that the 2 vols. of the product contain $2x$, and, if this is the case, combination cannot take place by addition, molecule uniting with molecule, for the numbers would, by this mode of union, be reduced to half. Potassium chloride and silver nitrate, when brought in contact in solution, give rise to a new compound; the chlorine and nitric acid separate from each molecule and change places, potassium nitrate and silver chloride being formed. This instance of double decomposition illustrates the mode of combination by substitution, by which the number of molecules is not changed, and Avogadro's hypothesis necessitates the assumption—

3. That the elementary bodies which combine without change of volume combine by substitution.

This assumption involves the other, that these elementary bodies are compounds, that each molecule contains at least two constituents, which, in the process of combination, separate and change places; and as it is to be supposed that all elementary bodies are formed substantially on the same plan, it is assumed—

4. That all molecules are compounds of smaller constituents, whose number in the elementary bodies is in most cases = 2. A distinction is, therefore, established between molecules and atoms, the smaller constituents, and these definitions are made:

"A molecule is the smallest particle of a compound or element that is capable of existence in a free state." . . .

"Atoms are the indivisible constituents of molecules. They are the smallest particles of elements that can take part in chemical reactions, and are, for the greater part, incapable of existence in the free state, but are always found in combination with other atoms, either of the same kind or of different kinds."†

One vol. of chlorine combines with 1 vol. of carbon monoxide, or with 1 vol. of ethylene, and the product is in either case 1 vol., condensation to one-half taking place. The monoxide as well as the ethylene are compounds; each molecule of the former consists of 1 carbon and 1 oxygen atom; combination with it cannot take place by substitution; each CO molecule must unite with one Cl atom; the number of molecules, $x + x$, contained in 2 vols. of the hydrogen compounds will, therefore, be contained likewise only in 2 vols. of either of the above chlorides, and it is assumed—

5. That the number of molecules represented by the molecular weight $= 2x$ is in every instance contained in 2 vols.

This assumption is supported by the general fact that the product of the combination of gaseous bodies is generally = 2 vols.; it involves the final and important conclusion—

6. That combination of compounds results always in condensation to 2 vols., whatever the sum of the volumes of the combining constituents may be.

These six conditions are involved in the hypothesis; a discrepancy of established facts with either of them will be fatal to it, and the unreserved and unhesitating statement of its error has been made on the ground of the not-to-be-expected fact that, even in the case of the elementary bodies on the behavior of which the hypothesis is based, none of the six conditions is fulfilled, as will now be shown.

It is erroneously stated* that one atom of hydrogen, of chlorine, etc., occupies 1 vol.; true only is that, if the weight of 2 vols. represents a certain number of molecules, the weight of 1 vol. represents one-half of that number; atoms being incapable of existence in the free state, their weights cannot be identified with the volume in which they are contained. The singular and not at all probable anomaly is thus presented that the volume of chlorine of specific gravity 35·5 should be made up of molecules of weight =71; nor would it be less singular that, while the molecular weight of Cl is 71 = 2 vols., half that amount should be sufficient to give rise to the molecular weight of the compound, HCl. The hypothesis is, however, to this effect, and the direct proof that the free particles contained in the volume of chlorine do not correspond to the weight 71, as assumed, but to the specific gravity, as is in the highest degree probable, cannot be given. But the decisive evidence of a body in every respect analogous to chlorine settles the question beyond dispute.

Cyanogen is a gaseous compound, the molecule of which, CN, is, according to the hypothesis, composed of 1 carbon and 1 nitrogen atom; when it combines with another body, substitution is not possible, one integral CN molecule will be joined by a particle of the combining body, and, as the number of CN molecules contained in 1 vol. is x, the molecular weight being $2x = 2$ vols. = 52, and each simple molecule gives rise to only one compound molecule, the 2 vols. are necessary for the production of the molecular weight, and, in conformity with condition 6, condensation to 2 vols. has to take place. This is now found not to be the case. Cyanogen forms two gaseous, or nearly gaseous, compounds, one with hydrogen, the other with chlorine; in either equal volumes unite without condensation. The specific gravity of gaseous CNH is 13·5; of CNCl, 30·75, 2 vols. CN + 2 vols. H or Cl forming 4 and not 2 vols. No doubt whatever is in these two cases possible concerning the facts involved. It is neither assumed nor maintained that the molecules contained in 1 vol. CN = 26 have the assumed molecular weight 52; and as the molecular weight is in this case identical with the specific gravity, the weight of the free particles in chlorine can likewise not be = 71, but must correspond with the specific gravity, and so, also, for H, Br, and T. If it were otherwise the unit of volume would contain of CN, x free particles, of Cl, etc., only $\frac{1}{2}x$.

With this inevitable conclusion, the whole theoretical structure, built on Avogadro's hypothesis, falls to the ground. The molecular weight of CNH is certainly = 2 vols., but these contain only 1 vol. of CN, and the molecular weights of H, Cl, Br, T, and CN are, therefore, only = 1 vol. Equal volumes do, consequently, not contain the same number of molecules. 1 vol. CN occupies in CNH 2 vols; the molecules can, therefore, not be equidistant in the two cases; a change of specific gravity having occurred. Nor do elements combine by substitution, nor is the distinction between atoms and molecules justified by facts, and the molecular weight is not invariably = 2 vols. The fact elicited that the molecular specific gravity is different and variable is of fundamental importance, for it is the principal cause of the failure of the hypothesis, and it is also the cause of the failure of the mathematical proof, which has given to the latter its great strength. The sameness and constancy of specific gravity is the express condition of the mathematical demonstration, as will be seen from the following statement of Prof. J. Cl. Maxwell, in his "Illustrations of the Dynamical Theory of Gases:"†

"We have seen that, on the hypothesis of elastic particles moving in straight lines, the pressure of a gas can be explained by the assumption that the square of the velocity is proportional directly to the absolute temperature and inversely to the specific gravity of the gas at constant temperature, so that at the same pressure and temperature the value, NMv^2, is the same for all gases. But we found in Prop. VI., that when two sets of particles communicate agitation to one another, the value of Mv^2 is the same in each. From this it appears that N, the number of particles in unit of volume, is the same for all gases at the same pressure and temperature. This result agrees with the chemical law that equal volumes of gases are chemically equivalent."

The conclusion that, at the same pressure and temperature, the value of NMv^2 is the same for all gases, is true only on the assumed constancy of the specific gravity of the gases to be compared; if, by chemical action, the specific gravity of one gas is reduced to ½, while that of another remains constant, then will N for the lighter gas be changed to ½ N. The support which the hypothesis has derived from mathematical conclusions vanishes thus on account of the change of specific gravity produced by chemical action.

More and not less decisive evidence of its fallacy is to be derived from the specific gravity of compounds of greater complexity.

Two vols. CNH + 2 vols. H_3N form not 2, but 4 vols. of CNH_4N; $27CNH + 17H_3N = 44 = 4$ vols., 1 vol. = 11. Deville and Troost found the specific gravity of ammonium cyanide at 100° C. = 0·79 = 11·4. As this body is formed at a high temperature by the union of carbon with ammonia, its vapor cannot be in a state of complete decomposition at 100° C.‡

The same experimenters found the vapor density of ammonium chloride at 350° C. = 1·00 = 14·43, 2 vols. HCl = 36·5 + 2 vols. H_3N = 17 = 53·5 = 4 vols., 1 vol. = 13·375. This temperature is near the boiling point; to assume that the vapor is then decomposed completely into a mixture of its constituents is to assume that decomposition does not take place gradually with rise of temperature as in other cases, but is complete at a temperature near the boiling point. But Deville brought the vapors of hydrochloric acid and ammonia in contact in an atmosphere of the vapor of mercury—that is, at 360° C.—and observed an increase to

* See "The Atomic Theory," by A. Wurtz (London, 1880), p. 36.

† "Principles of Theoretical Chemistry," by Ira Remsen, M.D., Ph.D., Professor of Chemistry in the Johns Hopkins University (Philadelphia, 1877), p. 36.

* See "The Atomic Theory," pp. 80, 96, 101, 119, and elsewhere.

† *Phil. Mag.*, vol. xix. (4), p. 30.

‡ *Comptes Rendus*, lvi., p. 895.

394·5°, which seems to leave no doubt that combination occurs at 360° C.* The complete decomposition has, nevertheless, been assumed as an established fact, the important experiments and results of Deville and Troost being mentioned neither in "The Atomic Theory" nor in the "Principles of Theoretical Chemistry." The assumption is proved to be erroneous by reference to the weights of the liquid and solid state. The specific gravity of liquid HCl is 1·27; of liquid H_3N, 0·6234; if combination occurred in accordance with condition 6, the weights 1·27 + 0·6234, which represent 2 vols., would be contained in 1 vol., and the specific gravity of liquid H_4NCl would be 1·8934. Experience indicates that the molecular aggregate is greater in the liquid than in the gaseous—greater in the solid than in the liquid state; the specific heat of ice, for instance, is half that of water, from which it may be concluded that the ice molecule has twice the weight of that of water, the molecular weights being inversely as the specific heats. The solid H_4NCl molecule is, therefore, in all probability, heavier, and its specific gravity, on this account, greater than the liquid; it can at least, by no means, be smaller. But the actual sp. gr., $NH_4Cl = 1{\cdot}528$, is smaller than that calculated for the liquid, and is irreconcilable with condensation, according to condition 6. Combination taking place without change of volume, the specific gravity of the liquid state is $\frac{1{\cdot}8934}{2} = 0{\cdot}9467$, and if the liquid aggregate is = 2, while the solid is = 3, the specific gravity of the latter is = 1·42, which is not far from the actual value. These considerations show that there can be no decomposition at the temperature of volatilization.

By comparing the specific gravities of solid bodies with each other in the free and in the combined state the difference of aggregation is not so marked, and the evidence obtained is to the same effect, and not at all doubtful. The comparison is easily made. Let a be the weight of the ammonium chloride contained in a compound, and b the weight of the other constituents, then is b in units of $a = \frac{b}{a}$ and the sum of weights $= 1 + \frac{b}{a}$, and if 1 is = 1·528, the specific gravity of NH_4Cl, the calculated sum of weights will express the specific gravity of the compound, which it will have, if the specific gravity of the ammonium chloride is the same in the free and in the combined state, and condensation takes place in accordance with condition 6. $\frac{b}{a}$ is in $2NH_4Cl.ZnCl_2 = \frac{136}{107}$; the sum of weights, $1{\cdot}528 \times 2{\cdot}27 = 3{\cdot}468$; the actual specific gravity, 1·72–1·77 (at 10° C.), or exactly $\frac{3{\cdot}468}{2} = 1{\cdot}734$. There is, consequently, no condensation, but combination, without change of volume, and, as H_4NCl represents 2 vols. + 2 vols. = 4 vols., the molecular weight of the compound must be 4 vols. + 4 vols. = 8 vols. This result is strikingly confirmed by other compounds of the same kind. In the following table column I. shows the calculated specific gravity when condensation to 2 vols. has occurred; column II., the quotient corresponding to the actual specific gravity; III., the actual specific gravity:†

	I.	II.	III.
$2NH_4Cl.HgCl_2.H_2O$	5·6536	$\frac{5{\cdot}6536}{2} = 2{\cdot}8268$	2·938
$2NH_4Cl.CuCl_2.2H_2O$	3·96	$\frac{3{\cdot}96}{2} = 1{\cdot}98$	1.977
$2NH_4Cl.PtCl4$	6·369	$\frac{6{\cdot}369}{2} = 3{\cdot}184$	3·009
$2NH_4Cl.SnCl_2.3H_2O$	4·998	$\frac{4{\cdot}998}{2} = 2{\cdot}499$	2·104
$2NH_4Cl.2HgCl_2.H_2O$	9·524	$\frac{9{\cdot}524}{2} = 4{\cdot}762$	3·822
$2AmCl.Am_4FeCy_6.3H_2O$ ..	6·326	$\frac{6{\cdot}326}{4} = 1{\cdot}58$	1·49
$NH_4Cl.MgCl_2.6H_2O$	7·325	$\frac{7{\cdot}325}{4} = 1{\cdot}831$	1·456

Series of similar compounds can be quoted with the same result in great numbers. The calculated specific gravities show that in no instance does combination take place with condensation to 2 vols. At the same time is the connection between the specific gravities of solids and their molecular weights revealed, and even the state of aggregation can in each case be determined. It appears that the laws of combination established for the gaseous state hold good also for the two other states, 4 vols. + 4 vols. combining to 8; 8 + 8 to 16; and it is found, on investigation, that the molecular weight of the most complex organic bodies is contained in 32 vols., which seems to be the limit of chemical action.

From all that has been said, it follows that Avogadro's hypothesis is absolutely without support. What will be the consequences of its overthrow? Very few considerations will show that not only will there be no loss to chemistry, but a wonderful simplification and harmony of facts.

The distinction made between atoms and molecules is, as has been seen, not founded on any natural fact; the combining weights of equal numbers of particles are, therefore, at the same time, the molecular and the equivalent weights, and these are represented for H, Cl, Br, I, CN, CO, C_2H_5, COCl, C_2H_4Cl, by 1 vol.; for HCl, HBr, HI, CNH, by 2 vols.; for CNH_4N, ClH_4N, by 4 vols., etc.

The number of molecules constituting the molecular weight being = x, and there being in CO = 14, $xC + xO$ molecules, it follows that the molecular weight of C is 6, of O, 8, and in all the oxides of the composition RO, R being the molecule of any element, the molecular weight of that element is the quantity combined with O = 8, and by this means, and O = 8 being equivalent to H = 1 and Cl = 35·5, the following molecular weights are found: Li, 7; Na, 23; K, 39; Ag, 108; S, 16; Se, 39·5; Te, 64; Hg, 100; Cu, 31·7; Zn, 32·5; Mn, 27·5; Fe, 28; Ni, 29·5; Co, 29·6; Cd, 56; Pb, 103·5; Cr, 26; Mg, 12; Ca, 20; Sr, 44; Ba, 68·5; Pt, 99.

If the formula NO were correct, the molecular weight of N would be = 7; but the quantity combining with H = 1 being 4·66, the inference is that 7 is the weight of 1½ molecules, and 1 vol. N + 1 vol. O = 2 vols. represents the compound N_3O_2, analogous to which is $12C + 14N = C_2N_3 = 1$ vol. When N 14 is = 3 molecules, B, 11; Al, 27·4; P, 31; As, 75; Sb, 122; Au, 196; Bi, 210, represent likewise each 3 molecules, and it becomes thus apparent that the mysterious property of valency assumed to be inherent in atoms, and at the same time variable, has no existence in nature; that all facts attributed to it find their explanation by substituting for the valency in every instance the requisite number of molecules. The existing formulas modified in this manner express the exact molecular composition, if the weight is not that of a multiple. The following are illustrations:

N_2O	$=N_6O_2$	$=2N_3O$
NO	=	$=N_3O_2$
N_2O_3	$=N_6O_6$	$=2N_3O_3$
NO_2	=	$=N_3O_4$
N_2O_5	$=N_6O_{10}$	$=2N_3O_5$
H_3N	=	$=H_3N_3$
H_2O	=	$=H_2O_2$
CO	$=C_2O_2$	$=2CO$
CO_2	$=C_2O_4$	$=2CO_2$
CH_4	$=C_2H_4$	$=2CH_2$ } *
C_2H_4	$=C_4H_4$	$=2C_2H_2$ }
H_3P	=	$=H_3P_3$
P_2O_3	$=P_6O_6$	$=2P_3O_3$
P_2O_5	$=P_6O_{10}$	$=2P_3O_5$
H_3PO_4	$=H_3P_3O_8$	$=H_3O_3P_3O_5$
$H_4P_2O_7$	$=H_4P_6O_{14}$	$=2H_2O_2P_3O_5$
HPO_3	$=HP_3O_6$	$=HOP_3O_5$
H_3PO_3	$=H_3P_3O_6$	$=H_3O_3P_3O_3$
H_3PO_2	$=(H_3P_3O_4)\times_2$	$=H_3O_3H_3P_3P_3O_5$
$3BaH_4(PO_2)_2$	$=Ba_6H_{12}P_{18}O_{24}$	$=3HOBa_2O_2H_3P_3P_3O_5$

These few examples illustrate the inconsiderable change involved with regard to the established formulas. A glance will suffice to notice the simplicity and the constancy of form of the new formulas, the accuracy with which they express the actual chemical facts, and the necessity of doubling the valency formula H_3PO_2 and of halving $H_4P_2O_7$.

The simplifications consist, therefore, chiefly: 1, in the elimination of the whole theory of valency; 2, in the disappearance of the distinction between atoms and molecules and the introduction of molecular weights, which are also the combining and equivalent weights; 3, in the conclusions to be derived from the mode of combination of solids and the difference of molecular specific gravity concerning the grouping of molecules in compounds, and the difference of properties of bodies, which have the same molecular composition.

As cause of the error of the hypothesis appears so far only the difference and variability of molecular specific gravity; but hydrogen, nitrogen, oxygen, chlorine, bromine, and iodine form a group of elements of the same molecular specific gravity, notwithstanding which 1 vol. of H, Cl, Br, or I, contains 1; 1 of O, 2; 1 of N, 3 molecules. This difference is due to a second cause of error, which, however, on account of the length of this communication, cannot now be discussed.

EDWARD VOGEL.

San Francisco, Cal., February, 1881.

* Comptes Rendus, lvi., p. 733; *American Journal of Science*, vol. xxxvi. (1863), p. 408.

† All the specific gravities used are taken from "The Constants of Nature," by Prof. F. W. Clarke, in vols. xii. and xiv., of the Smithsonian Miscellaneous Collections.

* It is assumed that marsh gas contains one, ethyline two carbon molecules, as the valency formula indicates.

A COLORING MATTER DERIVED FROM AN IMPURITY IN CERTAIN COMMERCIAL ACETIC ACIDS.

By M. GEORGES WITZ.†

COMMERCIAL acetic acid and pyroligneous acid, from the destructive distillation of wood, are colorless after they have been rectified, but in course of time they take a brownish or orange tint, which is so much the darker the less thoroughly they have been purified. Additions of chloride of lime, or of soda, carefully made, develop immediately a similar coloration, but of a much brighter tint, and in this manner their comparative purity may be judged at a glance. A modification of this test has enabled me to isolate a new principle, derived from an impurity existing in acetic acid, but which has hitherto escaped notice.

While engaged with the preparation of special aluminous mordants, for the purpose of fixing delicate colors, I observed first accidentally that nitric acid acts upon certain samples of acetic acid more strongly and distinctly than the chloride of lime, and that exactly in proportion to its percentage of nitrous acid (which is never wanting). Another advantage of this reaction is that a great excess of nitric acid does not appear to destroy the coloring matter, at least for a certain time—more than a day.

I soon afterwards substituted for nitric acid small quantities of the nitrites salt, which are instantly decomposed in the cold by acetic acid diluted with water;‡ and upon this fact I based an excellent method of preparation. The new orange coloring matter is very slightly soluble in acetic acid, and it is deposited in small brilliant violet-blue crystals, perfectly insoluble in water.

There is generally enough of this coloring matter in rectified acetic acid at 9½° Tw. (containing 40 per cent. of actual acetic acid), even in the best qualities employed in the arts, to produce notable quantities of this coloring matter. We shall see in the sequel how the proportion may be augmented if desired.

After having selected a specimen of acetic acid which gives the most intense coloration, it is placed in large, clear bottles, and there is added, at common temperatures, one one-thousandth part of nitrite of soda (not nitrate) dissolved in a little water. The extreme limits are from half to one and a half thousandths of the weight of the acid. The whole is then let to settle for some hours, or in weak samples for two days at most.

The floating crystals have fine iridescent reflections, and appear to be formed of steel-blue needles of from one to two millimeters in length. The last particles deposited are flocky, and of a more reddish tint.

The acid, which is colored of an intense red by the portion which remains in solution, is decanted, and may be employed without inconvenience in the arts, for instance in preparing the acetic nitrate of chrome. The crystals are washed with cold water, collected on a filter or on a sieve of silk, and dried at a low temperature. Sometimes even after two days the liquid remains supersaturated, and on agitation crystallization recommences, and yields distinct single crystals.

In many preparations I have obtained 30 grains of pure color from 22 lb. of the acetic acid as above, using 215 grains of the nitrite of soda, which is more than is necessary. Too large a quantity tends to lessen the yield, furnishing a crystalline deposit with a more violet shade. Heat is injurious. The yield from a cask of acid holding 572 lb. at 9½° Tw., with 9 oz. nitrite of soda, very fine flocculent crystals, measured approximately 24 fluid ounces.

I have given this new product the name of nitrosopyroligneine.

When the blue crystals are crushed they give an orange-brown powder, and when dissolved they show a color which varies from a reddish orange to a golden yellow. The coloring matter is most soluble in acetic acid, containing 86·94 per cent. of the real acid. Its tinctorial power equals, if it does not surpass, that of the acetate of rosaniline, though it is difficult to compare colors so different. Nitro-sopyroligneine is very sparingly soluble in alcohol, ether, benzol, petroleum spirit, choloform, but it dissolves readily in phenol and creosote. In bihydrated sulphuric acid it dissolves with a splendid blue color, which, after a few minutes, becomes violet, and ultimately a reddish brown.

Sulphuric acid more diluted gives a violet solution, which, in course of time, turns brownish yellow, and precipitates.

Lastly, sulphuric acid with 10 equivalents of water has practically no solvent action upon nitrosopyroligneine.

The crystals moistened with nitric acid dissolve of a blue color in bihydrated sulphuric acid, but the liquid soon turns to a yellow brown.

Nitric acid at 72° Tw. does not dissolve this substance; but its steel-blue color turns violet or reddish, and even a dirty orange. Dilute acid has no action. In the same manner concentrated muriatic acid has no action.

It is insoluble in a cold concentrated solution of phosphoric acid. With the aid of heat it dissolves with a reddish-orange color, and, on cooling, it separates out as a brown matter, unless a too prolonged action transforms it into an insoluble black powder.

The orange coloration of the acetic solution disappears completely by sulphurous acid without precipitation, and is restored by alkalies.

The contact of pure zinc in the cold entirely decolorizes the acetic solutions. The colorless liquid is restored to its bright orange tint by nitrites, chlorine, and persalts of iron, while sulphate of copper and mercuric chloride have no action.

Protochloride of tin at once decolorizes the same solutions, save a faint yellow tint.

An excess of ammonia or caustic soda added directly to the acetic solutions deepens the orange without altering its tone.

Cold caustic soda-lye does not dissolve the crystalline coloring matter, and seems to attack it very slowly. On adding water, we observe curious effects of dichroism; thus the crystals form at first iridescent groups, with a reflection like peach-blossom, but which in different lights appear of an orange-brown. The mixture, if diluted with water and heated to a boil, becomes successively a deep violet, indigo, and deep green, which does not change in the cold, and on continuing to heat an intense yellow.

In the deep green state the neutralization with a drop of acetic acid reproduces the ordinary orange shade.

In the yellow state the same neutralization renders the liquid absolutely colorless without affecting its limpidity. A slight orange tint may be reproduced with the addition of a little nitrite of soda.

Ammonia does not seem to act upon the crystalline matter either cold or boiling.

A hot solution of acetate of soda dissolves the crystals slightly.

Aniline yields interesting results. In the cold it slightly dissolves nitrosopyroligneine with an orange-red color. Hot, it is more soluble; the mass darkens, turns brown, then violet, and, if boiled in the open air, a splendid blue coloring matter is produced in abundance, probably a kind of azuline. The new blue color remains permanently dissolved in an excess of coloring matter without precipitation or cooling.

The spontaneous evaporation of the aniline leaves a coating with a coppery reflection, insoluble in water; alcohol dissolves out the more violet part, leaving a pure blue sparingly soluble in glacial acetic acid, but soluble in aniline. Monohydrated sulphuric acid dissolves it with a brownish-green color.

I have operated in the same manner with aniline and nitrate of soda without obtaining the action on boiling. If muriate of aniline and nitrite of soda are boiled with a little water there is produced a bright red matter collecting in tarry masses like coralline, and having the peculiar odor of phenol. The tarry matter dissolves in olive oil with a brown color; it is not very soluble in alcohol, and gives an orange precipitate with alkalies. A further addition of aniline, heated with the same mixture, gives only a reddish-orange color. We are, therefore, led to ascribe the production of the new blue color with aniline to a modification due to nitrosopyroligneine.

Results and colors more or less analogous with the above have also been obtained with the crystalline matter and pseudotoluidine; nevertheless, the purity of the sample requires ascertaining.

Acetic acid, containing the coloring matter, rapidly reduces nitrate of silver with the aid of light; at the same time, the liquid takes a red tint, which disappears on more complete reduction.

The crystalline matter, if dissolved in acetic acid and supersaturated with soda, reduces cupro-potassic liquid at a boil.

A weak solution of permanganate, added to the common acetic acid, gives a peculiar orange-red color; or excess destroys the color in a few moments.

Bichromate of potash alone with sulphuric acid has no action upon pure acetic acid, but it gives a red-brown color to commercial acetic acid, and finally destroys the coloring matter.

If crystalline nitrosopyroligneine is heated it remains for a time unchanged. It melts to a deep brown liquid at about 500° F., giving off faintly orange vapors of an empyreumatical odor. It burns with a brilliant but very smoky flame, and leaves behind a carbonaceous residue.—*Chemical Review.*

† Communicated to the Industrial Society of Rouen.

‡ A conflicting statement is found in the "Analytical Chemistry" of H. Rose, who says that "if nitrites are treated with acetic acid decomposition ensues only with the aid of heat, and even then only to a small extent."

NEW SYNTHESIS OF LEUCANILINE.

By OTTO FISCHER and P. GRIEFF.

PARANITROBENZALDEHYD is digested at 120° with aniline hydrochlorate and zinc chloride; the mass is dissolved at a boil in dilute sulphuric acid, filtered from the unchanged aldehyd, the filtrate mixed with strong soda lye and aniline if present; distilled off a yellow base is obtained, paranitrodiamidotriphenylmethan, which, if reduced with zinc powder and acetic acid, yields a leuco-base, in every respect identical with para-leucaniline, and which on oxidation passes into magenta.

ASPHALTUM.

ITS GEOLOGICAL ORIGIN, PREPARATION, AND APPLICATIONS.

THERE exists in nature an accidental mineralogical product which is met with under the most diverse conditions and often under most inexplicable ones. This product, known and utilized from biblical times, received from the ancients the name of *bitumen*, which modern science has preserved. This substance is found sometimes in a free state, sometimes mixed with clays, sometimes cementing together sand and stones (forming a sort of pudding stone), and at others impregnating calcareous rock. It is to the last-named product that common usage has given the name *asphaltum*. If the bitumen contained in any of these substances be isolated by chemical processes, we find in nearly all cases the

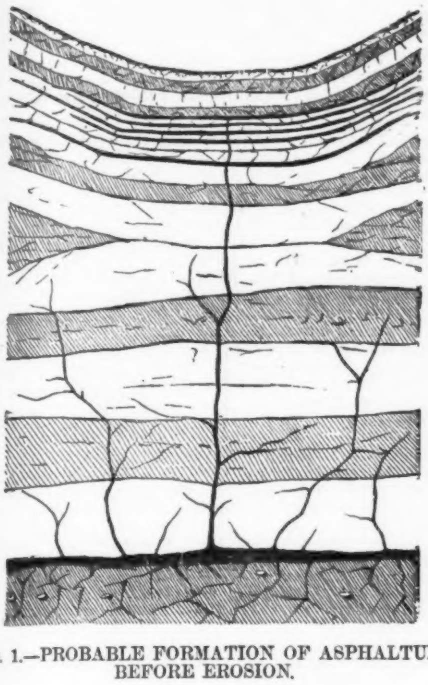


FIG. 1.—PROBABLE FORMATION OF ASPHALTUM. BEFORE EROSION.

same substance, having the same composition, the same consistency, and similar appearances. The empyreumatic odor alone which characterizes it sometimes varies and assumes a garlicky smell in those varieties which occur in the vicinity of volcanic districts. The analyses that have been made are in accord in giving it the following composition: Carbon, 87 per cent., hydrogen, 11·20 per cent., and oxygen, 1·80 per cent. (Boussingault.) Pure bitumen is a substance of a beautiful black color, reflecting a reddish light; solid at a low temperature, ductile at the temperature of the hand, liquid in the neighborhood of 50° or 60°, and very stable, since it loses scarcely one per cent. of its weight when heated to 250°. Its density is not very different from that of water. It is this bitumen which, permeating the pores of certain carbonates of lime, has given rise to *asphaltum*. The latter substance is without doubt the most extensive and most valuable

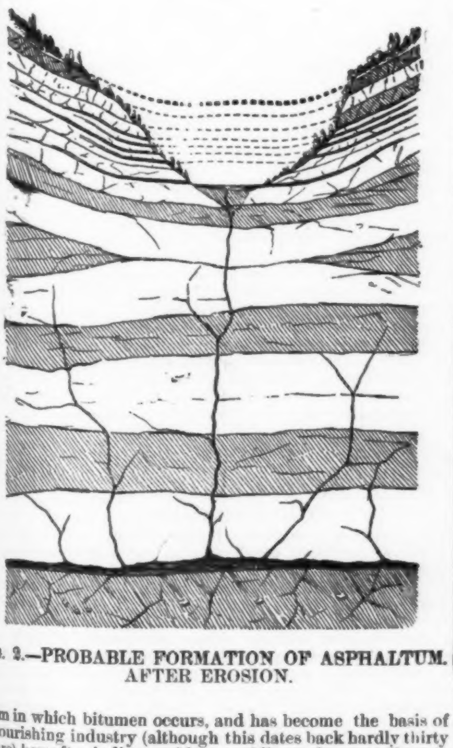


FIG. 2.—PROBABLE FORMATION OF ASPHALTUM. AFTER EROSION.

form in which bitumen occurs, and has become the basis of a flourishing industry (although this dates back hardly thirty years) hereafter indispensable to public works as well as to the embellishment of cities. It is a soft limestone impregnated naturally and intimately with bitumen. In fact, if a specimen of asphaltic rock be examined with the microscope, it will be found that each of its grains is covered with a thin pellicle of pure bitumen, by means of which it is cemented to the surrounding grains; so that the asphalt rock is in reality only a species of very fine-grained conglomerate cemented by bitumen. If we take a bit of this rock and heat it to a temperature of from 80° to 100°, the pellicle of bitumen softens, melts, and the cohesion of the asphalt disappears. Each grain of limestone separating mechanically from the others, the matter falls in the form of a powder. If we take this powder, while yet warm, or if we heat it after it has cooled, and then compress it so as to bring together the molecules in close juxtaposition, the latter again adhere, and when the matter has become cold we have the rock again, reconstructed exactly as it was in its primitive state, and having the same consistency and the same aspect. It is on this singular property that has been founded the industry of compressed asphalt pavements. Asphalt generally exists in regular strata in the Jurassic formation of the epoch called by geologists the Urgonian. These layers almost always exhibit themselves in the form of bowl-shaped deposits cut in two by a watercourse. Sometimes the deposit is a single one, sometimes it is multiple. In certain strata there are sometimes found as many as seven layers superposed and separated by banks of white limestone very clearly distinct from them. Those few scientists who have, up to the present, paid attention to this subject, have naturally disputed over the origin of this product and over the circumstances in regard to its formation. Some have insisted that bitumen made its appearance cotemporaneous with the deposition of the limestone, and that the molecules of the latter were deposited in a sea of bitumen.

Others have put forth the opinion that the deposits were due to the putrefaction and subsequent transformation into bituminous matter, of the organic portion of the mollusks which furnished the materials of the Oolitic formation. There is another theory which is still more plausible, and which may, therefore, be adopted until it can be disproved. It appears probable, from the data afforded by a study of bituminous regions, that at geological epochs as yet not well determined, masses of organic matters, buried beneath enormous deposits of Jurassic limestone and heated by the central fire, became vaporized and in this state sought an outlet through the terrestrial crust (Fig. 1). Some day this crust has cracked, a fissure has shown itself, and through this the bituminous vapors (which were under enormous pressure) found a passage open to them. These vapors have thus passed by those strata which were too compact to be penetrated by them; but, when they reached the Oolitic formation, they met, to the right and left of the fissure, layers of soft limestone which they impregnated (Fig. 2). So long as the pressure kept up the bitumen found its way through the pores of the calcareous rock and completely filled them, but gradually, as the pressure diminished, the impregnation slackened, and finally ceased altogether.

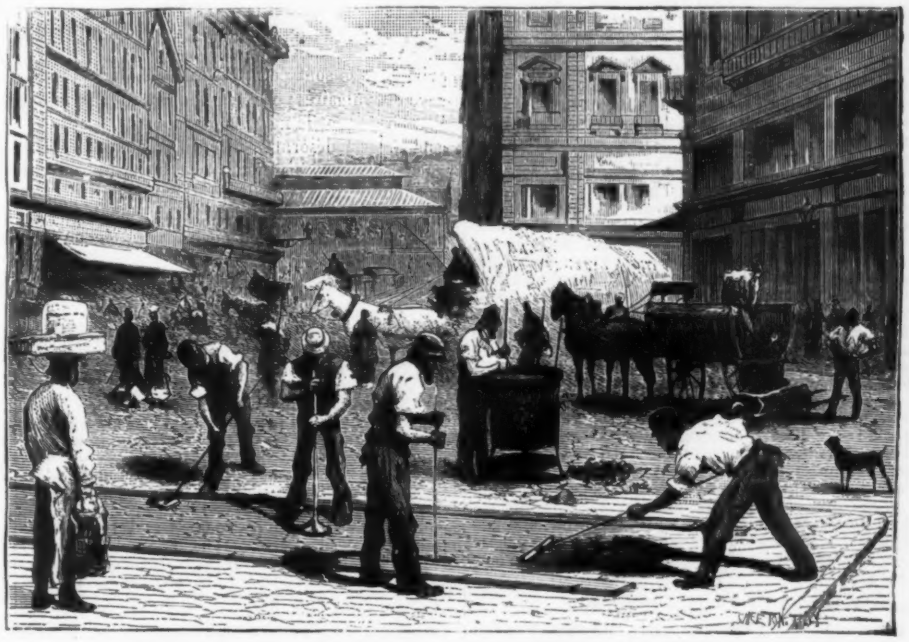


FIG. 3.—CONSTRUCTION OF PAVEMENTS FROM CRUDE ASPHALT, AT PARIS.

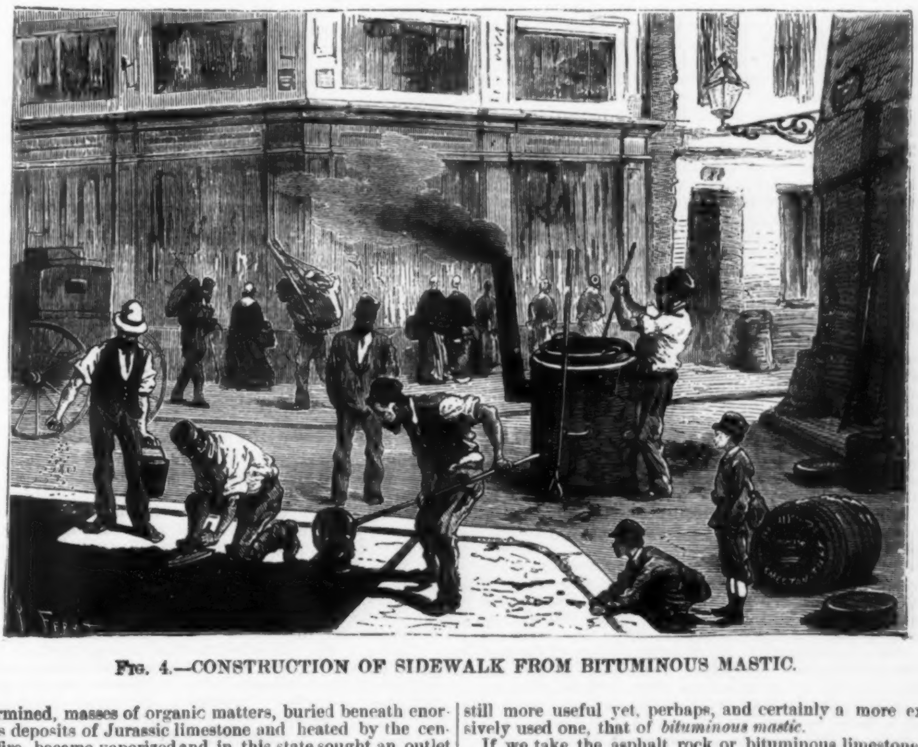


FIG. 4.—CONSTRUCTION OF SIDEWALK FROM BITUMINOUS MASTIC.

The exploitation of asphaltum mines is usually effected by blasting out galleries by means of gunpowder (no explosive gases being present), and, most of the time, the blasting holes can be drilled by an ordinary auger. In fact, the asphalt rock is a relatively soft material. Its compactness, however, being dependent on the temperature, its hardness, as found in the mines, increases in the open air during winter, and diminishes during the heat of summer to such a point that a simple exposure of a few days to the sun causes it to crumble into powder.

It was this same curious property which led to the discovery of the system of compressed asphalt pavements. At the beginning of its exploitation, the wagons which transported the rock from the Val-de-Travers deposit allowed some of it to drop here and there on the road, and these pieces, powdered and compressed by the wheels, formed at length a veritable asphalt pavement.

M. Merian, a Swiss engineer, was struck by the idea that this accidental invention might be utilized, and carried it out by asphalting the road from Travers to Pontarlier. The application was very rude, but the process was invented. This took place in 1849. In 1850, M. Darcy, inspector-general of bridges and roadways, in a report to the minister of public works on the public roads, declared that the future habitableness of cities would depend upon asphalt. He proposed at the same time to make an application of it on a portion of the boulevards. Nevertheless, it was not till 1854 that the first trial was made, and this was on Rue Bergère. Every one knows what the career of compressed asphalt has been since that epoch.

Asphalt is met with in the industry under another form still more useful yet, perhaps, and certainly a more extensively used one, that of *bituminous mastic*.

If we take the asphalt rock or bituminous limestone and powder it by any method, and throw this powder in small quantities at a time into melted bitumen, equal to 7 or 8 per cent. of the weight of the powder employed; and if we boil this mixture five or six hours, continuously stirring it the while by means of revolving agitators, we shall obtain a sort of paste, which, when run into moulds, constitutes what is called *bituminous mastic* or *cement*.

What takes place during this operation it is difficult to conjecture. Certain it is that a substance is formed which is chemically similar to the other, but physically it is an entirely different thing.

The manufacture of bituminous mastic constitutes a very

important industry, the annual production of the French factories alone reaching fifteen or twenty thousand tons; to which must be added a quantity ten to twenty times greater, due to imitations of the genuine article. We have now reached the second part of our subject—the uses and methods of application of crude asphaltum and of bituminous asphaltum.

USES AND APPLICATIONS OF CRUDE ASPHALTUM.

The principal one of the applications of this material is that of pavement making. The substance used for this purpose is called compressed asphaltum. It is scarcely necessary to go into the full details of the practical methods employed in making these pavements, since they are perhaps well known; it is sufficient to remark, in a general way, that the powdered asphalt rock is heated in rotary cylinders something like coffee-roasters, and then carried to the spot where it is to be used and where it is spread over a bed of beton and finally rolled. The good and bad qualities of asphalt are at present known to every one. The former lie in the good wheeling it affords, its noiselessness, its freedom from mud and dust, and the happy influence it exerts on the public health by these very properties; while the latter are found in the liability that horses have to slip up on it in wet weather, the too frequent necessity of destroying the asphalt crust to reach water and gas mains and service pipes, and, finally, the frequent necessity of repairs.

The advantages are beyond discussion. As for the alleged defects, without attempting to deny that they exist, it is safe to say that they are remediable, and that, if certain of them have not already been done away with, the system itself is not responsible for them. The slipping of horses on asphalt is an undeniable fact. At certain times, when there is a mist or fine rain, the dust of the road is changed to a slimy mud, and, until this has been washed off, the surface remains slippery. This inconvenience is a real one; but it may be pleaded in extenuation that a horse falling on asphalt receives less injury than he would if he fell on a macadamized or paved roadway. The second defect also undeniably exists at present; but as the municipal authorities of Paris cannot long defer relegating the water and gas mains to the sewers, as done at London, the evil is destined to disappear with its cause. The third defect is one easily remedied, and is due to two principal causes: The first one is the neglect of an essential, vital precaution—that of spreading the asphalt as a hot powder only upon a dry, inflexible, and impermeable bed. The second cause of destruction is due to the use of improper or badly prepared materials. We now come to the

APPLICATIONS OF BITUMINOUS MASTIC.

Some years ago the application of this substance was limited to the construction of sidewalks (Fig. 4) and to the covering of the exterior of vaults and arches; and it appeared then doubtful whether it could be extended much further. Its application at the present time, however, as a material for floors is so common that it is scarcely necessary to advert to the fact. It has entered into general practice in all building operations, and the methods of using it are within the reach of any laborer, and not confined as formerly to a certain craft possessing certain trade secrets which they religiously guarded.

An attentive observation of the properties of this singular substance, however, has enabled those who have employed it to some extent to find other uses for it; and upon these we may now dwell for a few moments. If bituminous mastic be spread out in a thin layer, upon a sidewalk for example, this fact will be remarked: In winter it is brittle, a sudden shock sufficing to break it; but in summer it becomes soft and malleable, and it is only by means of gravel that it is prevented from becoming appreciably disfigured by the feet of those who walk over it. But if, after sand or pebbles have been mixed with it, it be cast into blocks of a certain size, not only will it offer great resistance to a blow, but under no temperature of the atmosphere will it become misshapen. Struck by this unexpected property, a French engineer, M. Léon Malo, conceived the idea of utilizing it on a certain occasion, as follows: In 1862, having to put up a 50-horse power horizontal steam engine, he needed a monolith about 24 feet long and hollow in the center for the passage of the crank. Not being able to procure one except at very great expense, the thought struck him to employ as a substitute a block of bituminous mastic moulded and mixed with rubble. The engine thus mounted has been running for eighteen years in a room in which the temperature varies from 30° to 50°, and yet the asphalt block has not changed its shape a hundredth of an inch. Encouraged by his success, this same gentleman then endeavored to extend the range of use of the material, and, among other applications, he used it successfully as a foundation for a high-speed Carr crusher, which has been running for six years; but up to the present time the asphalt beton has not varied a particle in shape. Foundations on the same system were likewise constructed by Mr. Delano for the Toufflin grinder at the Paris Exhibition of 1878, and the speed of which was 1,400 revolutions per minute. Owing to the slight elasticity of the asphalt this enormous speed was attained without producing in the apparatus the least jar. M. Delano (who is director of the Asphalt Company of France) has also established, under the direction of Captain Naquet, foundations for a steam hammer for the artillery workshop at Vincennes. These examples are sufficient to show the properties of asphalt under a new light—extreme rigidity and tenacity, and at the same time elasticity without deformation at any temperature of the atmosphere.

Another property still more unexpected is that which makes asphalt an excellent preservative against fire.

Some twenty years ago M. Leon had laid an asphalt coating on the floor of a workshop. On the ground floor there were some furnaces which one day set fire to the floor beams above, and in an instant the whole lower surface of the floor was a sheet of flames. The flames were finally gaining the roof when the carbonized beams gave way and the planking fell. Then occurred a curious circumstance: the layer of asphalt, softened by the heat, fell in a single mass, as a thick heavy cloth might have done, suddenly enveloped the furnaces in its folds, and completely extinguished the fire. This experiment was repeated on a small scale, and as a consequence the Omnibus Company of Paris and several like associations have had the floors of their barns, etc., coated with the material.

In compact masses, mixed with stones or other heavy and inert materials, bituminous mastic is valuable for use in all foundation work which requires considerable tenacity and an elasticity without deformation; in addition is the advantage that it possesses of being easily moulded and not attackable by atmospheric or saline agencies. It is, then, an exceedingly interesting substance and one worthy of occupying the attention of scientists. However, it must be confessed that, with the exception of a few chemists and certain geologists who have considered with interest this mineralogical curiosity, each from his own point of view, there are as yet very few scientists who have done it the honor of a profound study. But it has taken, as if by force and without being invited, its place among the most useful, and, we might say, most indispensable materials of construction, and there appears to be destined for it a brilliant future.

A NEW VIOLET FOR PIGMENT.

By E. GUYARD.

MANY attempts have been made to turn to account the violet blue color obtained on adding an access of ammonia to a solution of a salt of copper. Guyard has to some degree succeeded. To an ammoniacal solution of blue vitriol he adds a solution of yellow prussiate. The precipitate thus obtained is well washed and dried at a heat of 338° F., when it loses ammonia and cyanogen, takes up oxygen, and becomes converted into a fine violet-colored pigment. If heated 392° F. a blue product is obtained, and at 482° F. a dull green.

The violet powder has more coloring power and covers better than ultramarine. If fifteen grains of it are stirred up with its own weight of water, thickened with sixty grains of solution of albumen, printed and steamed, the color is not in the least affected nor is it injured by the action of the air. Boiling lime-water turns it rather more to a blue, and chloride of lime gives it a more reddish tone. Concentrated solution of salt of tin turns it to a vinous red. Strong muriatic acid has little action, so that the new pigment may rank among the more permanent violet colors.—*Chem. Review.*

IMPROVED APPARATUS FOR BLEACHING, WASHING, CLEANING, DYEING, OR DISINFECTING TEXTILE GOODS.

By M. SCHARR.

THE object of this invention is to effect a great economy in the use of soap and other materials used in washing, dyeing, or bleaching, and to render practicable to use less time and labor in the processes of boiling and preparing for bleaching as well as in bleaching and dyeing.

Two or three recipients called steeping becks are connected respectively with reservoirs placed at a certain height by means of pipes and valves. The pipes are disposed so that the flow from each reservoir may take place into one of the sleeping becks, acting upon the goods placed in the latter, whether wool, woolen yarns, jute, China grass, cotton, linen, or silk.

The fiber is placed in the steeping beck, in which it is fixed by means of a grating and a cover, as may be desired; in this manner, on opening the valve, the liquid enters between the bottom of the beck and a false bottom perforated, so that the operator may be sure that it passes in a regular and clear stream through every portion of the goods contained in the beck.

The liquid rises in the beck and passes by an overflow into a gutter, which leads it into a reservoir, whence it may be conveyed into any other reservoir by means of a pump or an injector. To each reservoir and each steeping beck is connected a steam-pipe to regulate the heat and the pressure according as the process may require.

The process of bleaching is performed in the following manner:

The yarn is placed in a beck fitted with false bottom and lid, and the reservoirs are filled with the liquids required for steeping, cleaning, or preparing the fiber, and then for the process of bleaching itself.

When the beck is full a current of steam is passed in, if necessary, in order to soften the foreign matters which it is desirable to remove from the goods. The lye of fatty soaps, etc., in the reservoir, is brought to a boil by means of a jet of steam, which is kept up for half an hour; the liquid which has been employed for two or three times previously is run off into the sewer. The liquid of the second reservoir is then run into the same beck for the same length of time; this liquid is then raised by means of a pump and an injector into the first reservoir, now empty, and can be employed again after it has been strengthened a little. We then run into the same beck the liquid of the third reservoir, and raise it afterwards into the second reservoir, and pump into the third water at any required temperature, which then passes into the beck. The goods contained in the beck are now clean and suitably prepared for bleaching or dyeing.

While the goods are thus treated in this beck, those of the second and third may be treated in the same manner if desired.

In the process of dyeing the same method of operating may be adopted; the dye-bath may be prepared in the reservoirs.—*Moniteur de la Teinture.*

ON THE ULTIMATE ANALYSIS OF ORGANIC SALTS OF THE ALKALIES AND ALKALINE EARTHS.

By H. SCHWARTZ and P. PASTROVICH.

THE ultimate analysis of organic salts of the alkalies and alkaline earths is now generally performed by means of chromate of lead, which is more costly than copper oxide, as it cannot be regenerated, and as it admits of only one use of a combustion tube. It has been proposed to add pure fused potassium dichromate to the substance in the boat, and placing granulated copper oxide before it. Accurate determinations of carbon have been obtained in this manner, but a simultaneous estimation of the mineral constituent has to be dispensed with. If, however, as is now very general, the combustion is performed in a current of oxygen, the following method appears useful: We prepare pure mercury chromate by precipitating pure neutral potassium chromate with mercurous nitrate, and washing by decantation. It is dried and ignited in a porcelain capsule, leaving pure finely-divided chromic oxide. An excess of this is thoroughly mixed with the weighed organic salt, and placed in a platinum or porcelain boat, not too small. The combustion tube is open at both ends, and filled for two-thirds of its length with granular copper oxide, and ignited in a current of dry air. The charged boat is then introduced at the back, and the combustion is completed in the well-known manner. Pure dry oxygen is finally passed through for a sufficient time, whereby the carbonates of the alkalies and alkaline earths are entirely converted into neutral chromates, and the whole of the carbonic acid is obtained. Even nitrogenous substances may thus be burnt without danger of the formation of nitrogen oxides if the current of oxygen is kept moderate at the outset, so that the metallic copper placed in front may remain unoxidized till the last. If the boat is carefully drawn out when cold the base present in the salts may be accurately found by determining the chromates. In case of the soluble alkaline chromates this is performed most simply by means of a decinormal lead solution, which is run into the aqueous solution of the contents of the boat till a drop no longer gives a red precipitate with silver nitrate. In case of the chromates of the alkaline earths, it is more convenient to mix the contents of the boat with an excess of an acid solution of ferrous chloride of known strength, and to titrate the non-oxidized ferrous salt in the filtrate with permanganate.

In case of explosive nitro-products, such as potassium picrate, it is necessary to mix the substance first with chromic acid, and then with an excess of copper oxide. The separation of the chromate formed from the copper oxide presents no difficulty. The same method may be adopted in the analysis of carbonates.—*Berichte der Deutschen Chemischen Gesellschaft.*

PRODUCTION OF AMMONIA FROM THE NITROGEN OF THE AIR.

MULLER and GEISENBERGER draw the combustion gases of a furnace through caustic lime, where they are freed from carbonic acid, so that nearly pure nitrogen remains. In another apparatus hydrogen gas is produced by bringing water in contact with ignited coke, and the two gases, hydrogen and nitrogen, pass into a receptacle, where they are thoroughly mixed together, and subjected to the action of electric sparks. The ammonia is removed as soon as formed.

It may be useful to recapitulate the former attempts made to attain this object, unfortunately without success.

In 1864 Hunt patented a process for obtaining sal-ammoniac by passing a mixture of muriatic acid and nitrogen or air over red-hot coke, impregnated with chloride of iron or manganese. Wagner had made the same proposal as early as 1856, but he recommended chloride of magnesium in place of manganese.

Margueritte and De Sourdeval, and also Moermann-Laubuhr, make bricks of charcoal or coke, and an alkaline salt to promote the formation of cyanogen. These bricks are heated in a furnace, and air freed from oxygen, mixed with carbonic acid, is passed over them. A cyanide is thus formed, and converted into ammonia or an ammoniacal salt by four methods.

E. Solvay soaks coke in chloride of ammonium, and burns it so that the products of combustion, including sal-ammoniac, may be collected.

In 1877 Julien patented a process for forming ammonia by the action of the electric spark upon a mixture of hydrogen and nitrogen.

J. Swindells, in 1876, proposed to pass a mixture of air and steam over burning coke, and drive the gases into soda-lye. The escaping nitrogen and hydrogen are heated in chambers full of fragments of clay, and are to form ammonia.

In August 24, 1878, Rickman patented a process for passing a mixture of watery vapor and air into iron or clay retorts filled with coke or spongy iron, and heated to about 1,031° F. The watery vapor is decomposed by the ignited carbon, and its hydrogen combines with the nitrogen of the air to form ammonia.

The new patent evidently adopts Julien's principle for combining the gases. The manner in which the hydrogen and nitrogen are obtained is a secondary matter, presenting no difficulties.—*Chemiker Zeitung.*

PROCESS FOR BLEACHING BLOOD-ALBUMEN BY MEANS OF THE ELECTRIC LIGHT.

By LEON MANET.

THE process which the inventor has devised for decolorizing blood-albumen is based upon the action of the electric light. Under the prolonged influence of the electric rays the coloring matter which remains in the blood is gradually destroyed, the albumen loses its color, and becomes almost as white as that extracted from eggs.

The inventor makes no change at all in the present method of manufacturing blood-albumen. It is after the albumen has been separated from the clot, whether while still liquid or after it has been dried, that it is exposed to the influence of the electric radiations. The inventor arranged electric lights fitted with lenses or reflectors, so as to cast their light upon the albumen which is to be bleached. If it is still liquid the light is thrown upon the plates or trays which contain it in the drying stove.

These plates may be made of glass, so as to let the rays pass through them. If the albumen is dry the light can be thrown upon layers of the article arranged upon a stage. In either case the process varies in duration according as the albumen has been more or less completely separated from the clot. Under ordinary circumstances twenty-four hours will suffice to bring about a perfect decoloration. For more efficacy the electric light may be brought into action at the beginning of the process when the clot and the albumen are being separated.—*Moniteur des Produits Chimiques.*

NEW PROCESS OF DYEING FAST BLACK FOR MIXED FABRICS, WOOLEN FABRICS, COTTON FABRICS, AND FOR YARNS.

By M. J. CLARE, France.

THIS invention consists in preparing a bath with solutions of logwood, combined with an extract of bark quercitron, in proportions according to the intensity to be given to the dyed goods, and in adding to the bath a solution of sesquioxide of chrome and a solution of copper; sulphate, chloride, nitrate and acetate of chrome will answer well, and also the sulphate, chloride, nitrate, and acetate of copper. The fabrics or yarns are passed in the bath, and steeped; the black coloring matter is developed by means of an alkali solution. To dye cotton fabrics, the process can be modified as follows: A bath is made of extract of logwood and quercitron, or any other yellow coloring materials, to which is added a solution of alum of chrome and sulphate, chloride, nitrate, and acetate of copper, but the alum of chrome can be dispensed with. The fabrics are passed in the bath, then dyed, and afterwards passed in an alkali solution. If the fabrics to be dyed are of velvet, they are placed in a basket, then put in the bath, and pressure applied to the fabrics, to squeeze out any excess of dyeing mixture, which is returned in the bath; the fabrics are then dried, and afterwards passed in a solution of soda and water in the proportions of 1 lb. of soda to every 20 gallons of water; this sets the black. If the fabrics are of satin, or of any other kind of similar material, they are passed through the dye bath, then calendered, and then dried.—*Le Jacquard.*

HYDROPHOBIA—A GLEAM OF HOPE.

FAINT as is the glimmer, yet we cannot but think a tiny ray of light, very dim and uncertain it is true, has been thrown on this subject by the results of recent experiments communicated by some French physicians to the Académie de Medicine, Paris. Whether or not the discoveries made by M. Raynaud, and other members of the Faculty in France, will be considered, with those hopeful anticipations we indulge in, by others, we are unable to conjecture; the wish is, perhaps, parent to the thought with us, so we will presently place the experimental results referred to before our readers, who may judge for themselves. There can be no question that we are indebted to the continental schools of medicine for most of the little we know of hydrophobia, so that too much attention cannot be paid to any new facts (however remote from the main point in view) emanating from the quarter in question.

At the present moment we know absolutely nothing as to the composition of rabific virus; we know, however, that when transferred to other animals it produces a fatal disease resembling that developed in the animal from which it was derived. This specific principle is not of a volatile nature; that is to say, its germs are not conveyed like the spores of some diseases, through the medium of the air or breath, but it is what is technically termed a "fixed" virus in contradistinction to the above.

No organism whatever has been discovered in rabid saliva or other vehicles in which the poison is conveyed; the microscopist and chemist have sought in vain; in the saliva of the rabid animal as in the healthy, the elements to them are the same. According to the *Lancet*, however, M. Raynaud and his brother medicos have obtained remarkable results by inoculation with the virus, results which, if of a negative order, are still full of promise.

Last December a child which had been bitten by a mad dog died in Sainte Eugénie Hospital, suffering from all the usual symptoms of hydrophobia thirty days after the bite. Three series of inoculation experiments were made. Rabbits, on account of the readiness with which the disease can be transmitted to them, were used. Four were inoculated with the saliva before the child's death; three died rapidly, and the fourth recovered. Two inoculated with the blood recovered, thus corroborating the opinions held that the saliva, not the blood, is the medium. After the child's death inoculation from the mucus of the bronchial tubes was fatal, but juice from the salivary glands yielded doubtful results; the roots from the two fifth nerves of the child placed beneath the skin of a rabbit killed it, thus confirming the impression that the virus is abundant in the nervous system.

The third series of experiments was with the virus taken from dead rabbits inoculated into living ones, and it was in the course of these that some very remarkable results were obtained.

It was found that death occurred even when the blood was employed. The average interval between the inoculation and the death was about forty-five hours. This short period of incubation, together with the fact that inoculation from the rabbit to the dog was without effect, raised considerable doubts as to whether it was indeed rabies of which the rabbits died, and it was suggested that the animals died of septicæmia, since the saliva is a very putrescible liquid. M. Raynaud admitted that the symptoms were not similar to those of ordinary rabies, but still the fact of the virus being hydrophobic in the first instance remains. M. Pasteur, another experimentalist, stated that he also had inoculated some rabbits from the same patient, taking a little mucus from the mouth four hours after death, and with much the same effect; and in the blood of the rabbits, taken immediately after death, a microscopical organism was found altogether peculiar. It had the form of a small rod, slightly constricted in the middle, in length about the 1,000th part of a millimeter, or even less, and it was surrounded by the pale halo which may be seen around most microscopic organisms when they are placed in a certain focus. If these were placed in a cultivated liquid, as, for instance, in a decoction of veal, they rapidly multiplied, and always maintained the same form, but better defined. Sometimes the organisms changed to an 8-shaped form under certain conditions, arranged in 8-shaped chaplets. This organism, it was stated, was, without doubt, the cause of the illness and death of the inoculated rabbits, for others inoculated with the organisms, after their artificial cultivation, died with just the same symptoms. Is the disease thus inoculated, it is asked, rabies? M. Pasteur would not affirm this. It was certain that the saliva came from a child who suffered from rabies, but the practical absence of incubation in these cases was a difficulty in accepting the conclusion that the disease was rabies. Of one thing M. Pasteur was sure—that it was not septicæmia. The organism was not the same, and the symptoms were not the same. In his experience the disease was a new one. Guinea pigs inoculated with it did not suffer at all, although they are animals closely allied to the rabbit. On the other hand, the disease was readily transmissible to a dog, which died in three or four days, but presented no symptoms of rabies.

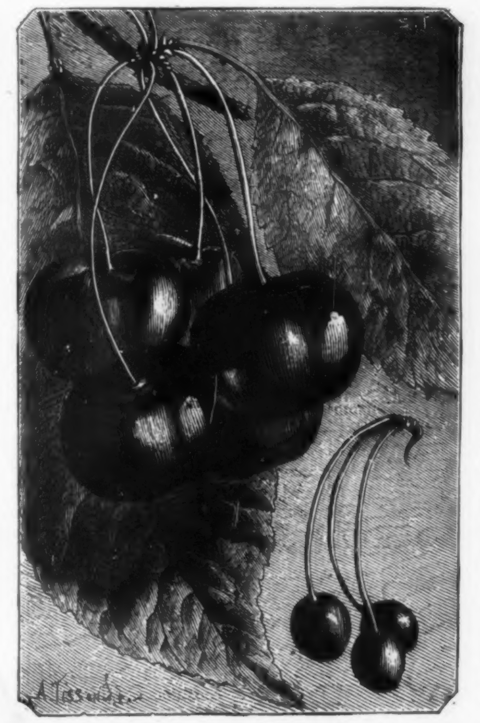
At a subsequent meeting of the Academy, M. Pasteur brought what, we think, strong proof that the disease communicated to the rabbits was not septicæmia, as suggested by the negative result on the guinea pigs. He showed guinea pigs inoculated with considerable quantities of the new organism, and all the animals were in perfect health. On the other hand, a rabbit inoculated with the same material died in a few hours. In a series of comparative experiments he inoculated some guinea pigs with undoubted germs of the vibrios of septicæmia, which caused rapid death from septicæmia. From these facts he considered the conclusion justified that the inoculation of the rabbits with the saliva of the hydrophobic child has given rise to a virulent disease, which is absolutely new, and which is characterized by a special organism.

Some experiments by M. Galtier, of Lyons, were also communicated. He obtained what he regarded as rabies in the guinea pig with inoculation of the saliva. By cultivating the saliva of a rabid dog in the saliva of healthy animals, he also obtained an organism similar in form to these above described. But, contrary to the results obtained by M. Pasteur with his organism, which was cultivated in an indifferent liquid, M. Galtier found that guinea pigs inoculated with this saliva died in from eight to twenty-two days. Other guinea pigs inoculated with the saliva of the first died in from the fourth to the fifth day. By treating different mucous membranes with the saliva of rabid animals, M. Galtier believes that he has conferred on animals an immunity to rabies. He states that he has found that the subcutaneous injection of the saliva of a rabid dog was capable of producing local inflammation and septicæmia, which caused death in from four to eight days. The injection beneath the skin of sheep of the juice obtained by squeezing the cerebral substance of rabid dogs caused death in a single day. The disease did not appear to be rabies, for the saliva of the sheep did not communicate the disease to rabbits.

At present it is impossible to interpret the meaning of these negative and occasionally contradictory results, we admit, but their great importance cannot be denied; and we think in saying there is a gleam of hope that the fatal disease, hydrophobia which has defied the medical profession for thousands of years, may yet be successfully combated.—*Land and Water.*

ART AND NATURE.

SOME time ago we gave in the SUPPLEMENT, under the title of "Art and Nature," a representation of a wasp's sting, a rose prickle, and a needle point placed side by side, and all magnified the same number of diameters. The point made by the hand of man was shown to be (when viewed under the microscope) blunt and rough, while the two objects of nature were exceedingly smooth, sharp, and delicate. In a late number of the *Revue Horticole* there is an interesting illustrated article, by Mr. E. A. Carrière, which permits us to see that, in some cases at least, man can, by his art, improve on nature. This is strikingly shown in the annexed cut, which shows how the art of the horticulturist has improved on one of our common fruits—the cherry. The bunch of small fruit to the right consists of common wild cherries of the woods, while the cherries to the left are the offspring of these raised by human art to the rank of large and luscious fruit. Art does not create, properly speaking,



CULTIVATED AND WILD CHERRIES. Natural Size.

and it can never be compared with nature; but by continuity of work, it improves and brings to perfection, and can even bring about true transformations in the beings which exist on the surface of the globe. The cherry, as may be here seen, is a remarkable instance of this fact.

THE RELATION OF APICULTURE TO SCIENCE.*

By A. J. COOK.

I ONCE heard a well known professor and scientist, than whom there is no better student of American agriculture, remark that the art of agriculture was founded almost wholly upon empiricism; and that all it had to thank science for was that the latter explained what had already been determined by the empiric method. Whether this be true or not, the reverse is most certainly true of practical entomology. Economic entomology rests almost wholly upon science. So, too, apiculture, as practiced to-day, owes its very existence to science. Fear deters most people from bee-keeping, unless a desire to study bees, and to know more of the nature and habits of these marvels of nature, impels to that close association with bees which practical apiculture demands.

For this reason, there is no class of men engaged in manual labor pursuits which possesses the intelligence and enthusiasm which characterize apiarists, or which practices so much that is really scientific. The successful apiarist of to-day must be able to inspect every part of his hives; must be constantly familiar with the precise condition of every colony of his bees; must be possessed of quick and accurate powers of observation. Thus we understand why science has gleaned so much from practical apiculture.

The nature of the several bees in each colony, as to sex, function, and longevity, is now well known to every intelligent apiarist. The peculiar characteristics of queen, drones, and workers, and the peculiar duties of workers of different ages, are matters of daily observation.

The queen is seen to lay three or four eggs per minute, and the apiarist, by adding comb with empty cells, proves that she may lay as many as 4,000 eggs per day. Aristotle was correct, then, in calling the queen the mother, and Virgil wrong in pronouncing her to be the king. Her hatred of rivals is easily shown by the certain combat, fatal to one of them, when two queens are placed together. This enmity induces swarming, as bees rarely suffer a plurality of queens in the same hive. In swarming the queen never leads, yet the special place of clustering is usually determined by the queen. Unless the queen accompanies the swarm, the latter will always return to the hive.

By clipping one wing of a virgin queen, so that flight will ever after be impossible, the bee-keeper quickly proves the correctness of the great Huber's discovery, that queens always mate on the wing. The same experiment proves the correctness of Dzierzon's more wonderful discovery, that drone bees are a result of agamic reproduction. No queen whose wing is clipped while yet a virgin, so far as I have observed—and I have tried the experiment many times—will ever lay eggs that will produce other than drone bees. It is also true that if a queen is forced to virginity for three or four weeks, she will always remain a virgin.

Upon the queen's return from her mating flight, we may observe the evidence of success, as she always, if successful, bears away a portion of the drone's reproductive organs, which remain attached to the queen for some hours.

It was a theory of the late Samuel Wagner that the placing of unimpregnated eggs in the larger cells of the drone comb, and the impregnated ones in the smaller worker cells, was simply automatic. The pressure from the smaller cell upon the queen's abdomen forced the sperm cells from the spermatheca as the eggs passed by. As there would be no such pressure from the larger drone cells, the spermatozoa would not be extruded from the spermatheca. Practical bee-keepers have shown this to be untrue.

Queens have been seen to lay eggs in the still larger queen cells, which eggs are always impregnated. The queen often lays in worker cells, where the walls are but just commenced, and where there is no compression; yet such eggs are always impregnated. That the bringing of the sperm cells into connection with the germ cells, or the withholding of them, as the eggs are to produce females or males, is a matter of volition with the queen, is sustained by the muscular character of the spermatheca. It is a curious fact, that young queens, when they first commence to lay, often put several drone eggs into worker cells, though after the first day or two they generally deposit only impregnated eggs for the first season. It seems probable that the muscles of the seminal sack of the queen do not act efficiently till somewhat in practice.

An anomalous physiological fact is illustrated in the flight of the queen when swarming takes place. Though she may not have used her wings since her marriage flight, possibly for two or more years, yet the muscles are by no means atrophied, as shown by her rapid flight, often for several miles, *en route*, to her future home.

The reason why a few impregnated eggs develop into queens, while thousands of the same produce worker bees, appears to be wholly due to quality and quantity of food. They receive much more and much richer food. The enlarged cell is necessary to a full sized queen, but not to a queen. The exceptional position of queen cells is simply for convenience, as it is not important.

Direct observation, as also her removal from the hive, shows that the only function of the queen is to lay eggs.

I have known a queen to lay with no abatement of fertility for five years, though often in one or two years she ceases to be prolific, either from her own impotency, or from a depletion of the spermatheca, in which case only drone bees are produced. Usually the worker bees arrange to supersede the queen before she becomes an exclusive drone producer.

Common observation proves that the drones are males, that they are great eaters, and that they have no function in the economy of the hive, except the sexual function. As already explained, the drone loses a portion of his reproductive organs, in mating, which act is attended with immediate death.

Though doubt is sometimes expressed as to the origin of drones by parthenogenesis, there is no such doubt among intelligent apiarists. If the wing of the virgin queen is clipped, or the entrance to the hive so contracted that she cannot fly, or again, if she is reared when there are no drones, she will be not sterile, but from her eggs will come only drones. Often these will be in the small cells, when the drones will be no larger that the workers. The eggs from fertile worker bees, and also from old queens, with depleted spermathecas, will likewise produce only drones. In appearance and structure these drones are every way normal. I have no doubt but that they are functionally perfect.

There is an interesting fact connected with the appearance and disappearance of drones, whose explanation seems to call for an intelligence above instinct. As the colonies become very populous in spring, the worker bees build drone comb, and rarely even tear down and replace worker with drone cells, and the queen lays the unimpregnated eggs in such cells, preparatory to rearing queens and to swarming. If we remove a queen none but drone comb will be built. Now suppose a colony is strong and preparing to swarm, and suddenly, from lack of bloom, continuous rains or great drought, the secretion of nectar suddenly stops. Honey gathering of course ceases, brood rearing is discontinued, and, not infrequently, the bees kill all the drones, and even drag the larvæ and pupæ from the cells. As soon as the honey harvest is hopelessly cut short by the autumn frosts, the worker bees commence at once to bite and worry the drones, till the latter are driven forth to die. But if the colony be queenless, or if the queen has become superannuated, the drones will be permitted to remain in the hive all winter. The fate of the drones hangs on the prosperity of the colony. With rapid increase of bees and honey they are safe; adversity in these respects, unless caused by loss or impotency of the queen, betokens their speedy extinction.

Drones are tolerated in a strange colony, which is not generally true of either the queen or workers.

The longevity of drone bees, as we have seen, is largely dependent upon circumstances. There is good reason to believe that they may live through the entire season.

The worker bees are imperfectly developed females, which from receiving less and different food, while larvæ, are immature in their sexual development. A worker larva, less than three days from hatching, will, if given more and richer food, develop into a queen. If an apiarist allows a colony to go queenless for a long time, fertile workers are almost sure to appear, from whose eggs, however, none but drones are produced. Some apiarists suppose that such workers receive, perhaps by accident, a richer and more abundant pabulum. I have wondered if this might not verify Lamarck's idea of evolution. The bee desires eggs, and the deeply felt want induces the extra ovarian development.

The worker bees are shorter than the drones and queen, and less robust than are the drones. Their wings are small but strong, and move very rapidly in flight. When the bees are angry the rapidity is still more marked, and there is a corresponding increase of pitch to the hum.

The workers, as the name implies, do all the work of the hive, hence a reason for their better developed mandibles, with which they cut comb, remove cappings, and dig pollen from the cells; their longer tongues and maxillæ, with which they extract nectar from deep tubular flowers, and the deep

* Read before the Entomological Section of the A. A. A. of S.

baskets on their posterior tibiæ and basal tarsi, which are wanting in the queen and drones, in which they carry pollen and propolis to their hives. As they protect the hives from intrusion, they need and possess a better developed sting than that of the queen, which is only used in dispatching rivals.

By the introduction of Italian bees, which differ greatly in color from the German or black bees, bee-keepers have learned that the old bees for the most part gather the honey pollen and propolis while the young bees remain within the hive and secrete the wax, build the comb, feed the brood, and cap the brood cells, though the young bees will do the work of the young ones if for any reason the natural equilibrium of the colony is destroyed.

That bees possess and use the sense of smell is obvious to the apiarist. If he unite two colonies, they often engage in fierce combat, which only terminates when one of the parties is vanquished. By smoking, sprinkling with an essence, or otherwise giving to both the colonies the same scent previous to the union, perfect peace and harmony is secured. The same fact leads to somewhat similar precautionary measures in introducing queens.

In going to any place, bees seem to be guided by direction rather than sight. Thus if we move a hive, but for one or two feet, the bees will, for days, descend to the old position, and then turn abruptly to the hive. I have been led to notice a strange exception to this: by placing honey on a porch of one of two houses that are exactly alike, but about five rods apart, many bees were misled and swarmed about the porch on which there was no honey. The experiment was several times repeated.

Experience shows that bees will winter quite as well with pure honey or sugar sirup for food, as though they had pollen with it. They may be kept healthy at least for a time, in confinement, in summer, on a pure hydrocarbonaceous diet, and will secrete wax and make comb with the usual activity. But pollen is a *sine qua non* to brood rearing. Probably it is also necessary for the old bees at times of great activity. Bees also need water. Unless very active, this want seems to be met by the water of the honey; but in shipping bees they are now generally fed with candy or crystallized sugar, and unless water is added, they perish in a few days.

Nectar, as gathered from the flowers, contains much more water than does the honey. The bees leave the nectar, which is often nearly as thin as water, some time before capping, until the necessary evaporation has transpired. Bee-keepers call this the curing process. Some nectar is so thick that it is capped very soon, though frequently it remains for days, and rarely is it of such a nature that it does not thicken, and the bees refuse to cap it at all. Such nectar, usually from bark, lice, etc., is unwholesome, and unfit food even for the bees. If thin nectar is extracted, bee-keepers evaporate the moisture from it by artificial heat, as it does not preserve its quality unless rid of the superfluous water.

One of the most terrible disasters that can befall the apiarist is to become the victim of foul brood. In this terrible disease a fungus attacks the brood, which causes it to become putrid and disgusting. It is very contagious. The disease is common in Europe, and has brought ruin and discouragement to apiarists in several of our own States. Spraying with salicylic acid has been found an efficient cure.

The enemies of bees is certainly a matter of interest to all scientists, and especially to zoologists. Among mammals, shrews and mice are often quite destructive to bees. The king bird, *Tyrannus carolinensis*, captures worker bees, although it is partial to drones. Toads and frogs seem to lap up bees with no inconsiderable relish, and often work quite successfully to deplete the hives.

Bees have many and formidable foes among insects. In the order Hymenoptera, a species of Xylocopa, probably *X. micans*, has been observed to kill bees in North Carolina. The cow killer, *Mutilla coccinea*, destroys bees in the States from central Illinois to Texas. It has been reported several times that ants are at times a serious foe to the honey bee. It is stated that they not only worry the bees by invading the hive, but that they sometimes kill both the queen and workers.

The only lepidopterous insect which annoys American apiarists is the bee moth, *Galleria cereana*. And even this is no dread to the intelligent apiarist. It is found that strong colonies of bees, and no other, pay, and especially if Italians, will always defend themselves against this enemy. It is only weak or queenless colonies that succumb to this foe.

Among Diptera, *Bombylius mexicanus*, is reported to enter the hives in Texas without resistance, and lays its eggs where the prospective larvæ will be nourished and cared for, without labor on the part of the mother fly. The family Asilidæ affords the most serious dipterous pests to the apiarists. Of these there are at least three species of Asilus, two of Mallophora, two of Promachus, two of Laphria, and two of Erax, that catch and kill bees. These predacious flies work the most serious mischief south, but are not exempt from blame even as far north as Ontario. A parasitic fly of the family Tachinidæ is destructive to bees in several of the States.

In importing bees, the bee louse, *Braula cæca*, has been introduced from Europe; but so far it promises to do little harm in our country.

Among Heteroptera, *Phymata erosa* is a dreaded foe of the honey bee. From its close mimicry of the flowers of many composite plants, in which it is wont to hide, it finds it easy to grasp the bees with its unique anterior legs, when it soon sucks out their life juices. *Mantis carolina* kills bees from Central Illinois to the Gulf.

Many of the Libellulidæ, chief among which is *Anax junius*, are so fierce in their onslaught on bees that they have been termed bee-hawks. These marauders depredate in all sections of our country.

I need not speak, at this time, of the value of bees in fertilizing flowers, as that has been ably discussed by our botanical friends That bees ver injure buckwheat or other plants, by seeking nectar from their bloom, as is sometimes claimed, is known to be erroneous by all present. That they are equally harmless to grapes and other soft-skinned fruits is not so generally granted. Personally, I have never seen a case, though I have several times gone quite a distance to see them at the request of positive individuals. In each case, the bees were found never to attack sound fruit, but only to sip from such as had burst, or been torn by other insects or by birds. While I am not positive that bees are never guilty of such wrong-doing, I do feel certain that such actions, if ever true, are quite exceptional. I have lived in California in the midst of apiaries and vineyards, and I have yet to see the first case of such depravity among bees.

The two great improvements in apiculture since the Langstroth hive and scientific knowledge gave the apiarist such perfect control over his bees, are the extractor and comb foundation, both of which are recent inventions. In both cases the thought came from Germans, but perfection in carrying it out is due to Yankee genius.

The honey extractor works on the principle of centrifugal force, and by its use honey may be thrown from the combs before it is capped over, or afterward if the cappings be first removed with a knife. By this practice the comb is used over and over again, and as a result, at least twice as much honey can be secured. Experiment proves that it takes at least twenty pounds of honey to secure one of comb, besides the time of secretion is lost, as bees are usually quiet when employed in secreting the wax-scales.

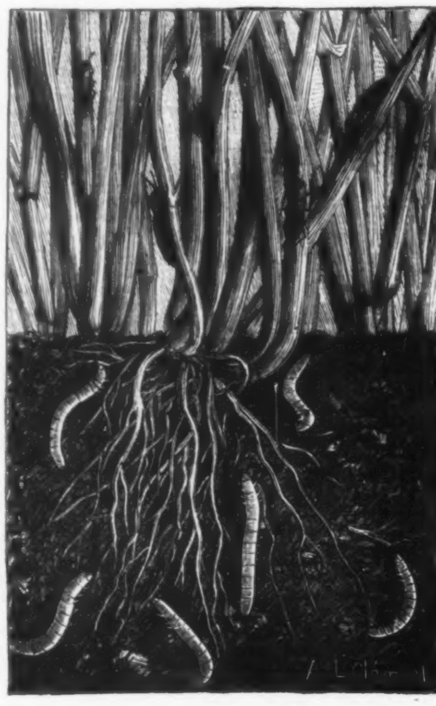
Extracting is often very necessary to furnish room for the queen, so that she may lay eggs. In times of great honey secretion, the workers so fill the cells with honey that the queen finds no place for her eggs, so brood-rearing ceases, and as the workers live only for a few weeks in the active season, depletion of the hive is rapid and sometimes is carried to a fatal extent.

When bees cease gathering from lack of nectar secretion the queen stops laying and all brood-rearing ceases. Nothing is found to pay the apiarist so well as to feed sparingly, whenever there is a cessation from gathering honey, and so keep his colonies strong. The extracted honey furnishes a cheap and excellent food for this purpose.

Comb foundation is made from pure bees-wax, and is a perfect copy of honey comb as just commenced by the bees, except that it is much thicker. When given to the bees, they at once accept it, thin it to the usual thickness of natural comb, and use the parings to complete the cells. This saves the time and work of wax secretion and comb building, and secures straight combs and exclusive worker cells.—*American Naturalist.*

SPRING-BEETLES AND WIRE-WORMS.

THE family of beetles known as Elaters, or spring-beetles (*Elateridæ*), are well known by the faculty they have of throwing themselves upward into the air with a jerk when laid on their backs. On the under side of the breast, between the bases of the first pair of legs, there is a short, blunt spine, the point of which is usually concealed in a corresponding part behind it. When the insect, by any accident, falls upon its back, its legs are so short and its back



WIRE-WORMS AND SPRING-BEETLES.

is so convex that it is unable to turn itself over. It then folds its legs close to its body, bends back the head and thorax, and thus unsheathes its breast-spine; then by suddenly straightening its body, the point of the spine is made to strike with force upon the edge of the sheath, which gives it the power of a spring, and reacts on the body of the insect so as to throw it perpendicularly into the air. When it falls, if it does not come down on its feet, it repeats its exertions until its object is effected. The largest of our spring-beetles, the "eyed elater," is well known to most children, to whom it affords curiosity and amusement in its leaping operations when laid upon its back. The larvæ or grubs of the elaters live upon wood and roots, and often prove very injurious to vegetation. Some are confined to old or decaying trees, while others devour the roots of herbaceous plants such as potatoes, corn, wheat, turnips, grass, etc. In England and also in America they are called wire-worms, from their slenderness and extreme hardness. In this country, however, the same common name is also applied to the myriapod, which is not a true insect. The European wire-worm is said to live in its feeding or larva state not less than five years, during the greater part of this time being supported by devouring the roots of grasses and cereals, annually causing a large diminution of the produce, and sometimes destroying whole crops. It is said to be particularly injurious in gardens recently converted from pasture lands. We have, in America, several grubs allied to this destructive insect, which are quite common in land newly broken up; but fortunately as yet their ravages are inconsiderable. They may be expected to increase in proportion as they are disturbed and deprived of their usual articles of food, and while we continue to destroy their natural enemies, the birds.

After their last transformation spring-beetles may be seen rising out of the ground during the summer, especially in June, and betaking themselves to trees and fences and occasionally to flowers. They creep slowly, and generally fall to the ground on being touched. They fly both by day and night. Their food, in the beetle state, appears to be chiefly derived from flowers; but some devour the tender leaves of plants.

As before stated, the bodies of the larvæ, or wire-worms, are excessively hard. A writer in a French contemporary says that experiment has shown that in some cases it is almost impossible to crush them by passing over them a roller weighing over two thousand pounds. This mode of destruction appears therefore to be impracticable. Very numerous methods have been employed by farmers to effect the destruction of these pests, but the results so far do not seem to have been satisfactory. For example, rotation of crops has been suggested as a possible remedy against the scourge—that is, planting different crops year after year that the larvæ will not feed upon. Unfortunately, however, it has been found that they cannot be starved out, but will soon accommodate themselves to their new food, and go on in their cycle of development. Such means having failed, chemical ones have been tried, but with scarcely any better results, since the amount of any chemical substance necessary to destroy them likewise kills the crops. Sulphocarbonate of potash has been discovered to be a powerful insecticide in case of the phylloxera, and might answer equally well as a remedy against the wire-worm, but unfortunately the cost of the article is high when the value of the plants to be preserved is taken into consideration.

The night-shining elater (*E. noctiluens*), or celebrated *cucuio* or fire-beetle of the West Indies, belongs to the same family of insects, and resembles our eyed elater somewhat in form. It is frequently brought alive to this country as a curiosity. It gives out a strong light from two transparent eye-like spots on the thorax, and from the segments of its body beneath. Like its cogeners, it feeds on vegetable substances, the pulp of the sugar-cane being its natural food. Its grub is said to be very injurious to this plant, by devouring its roots.

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